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A general system of sewage disposal for the valley of the Passaic River in the State of New Jersey is to be considered by a commission of three residents of the State to be appointed by the Governor. A bill to this effect passed the New Jersey Legislature on Feb. 25. The commission will have power to employ such engineering and other assistance as may be necessary. It may include in its report plans and estimates for the work methods of executing it and recommendations as to the apportionment of the cost. The sum of $10,000 is appropriated for the purposes of the investigation, but all expenditures are to be subject to the approval of the Governor of the State. The sewage of Paterson, Passaic Orange, Montclair, Bloomfield, East Orange and a part of Newark now discharges into the river. During the very low water of last summer the stenches from the stream gave rise to numerous and vigorous complaints from adjacent residents. The State Board of Health called a conference of representatives of local boards of health at Trenton in September, to discuss the matter. At a subsequent meeting of representatives of local boards it was agreed to attempt to secure the passage through the Legislature of a bill referring the whole subject to the State Board of Health for investigation and report. A committee consisting of Dr. J. L. Leal, Health Officer of Paterson, as chairman, three other physicians, and Mr. M. N. Baker, of the editorial staff of this journal, was appointed to push the bill. A majority of the committee claimed that for various reasons it was necessary to alter the bill so as to place the investigation in the hands of a commission instead of the State Board of Health, and to strike out all reference to protecting public water supplies. In that form the bill passed the Senate 17 to 0, and the House 49 to 4. The passage of the bill in its present shape is largely due to the exertions of Dr. Leal.

Jersey City will probably make another attempt to secure a pure water supply. It is reported that the Street and Water Commissioners decided on Feb. 25 to have new specifications drawn, and that formal action to that end, including the appointment of an engineer, will be taken on Feb. 27. It is said that bids will be received only on a gravity supply from the Rockaway River. This will be the fifth call for bids which the city has made within some five years. A contract was awarded last Fall but was upset in the courts, as set forth in our issue of Jan. 30.

About 5½ miles of 12 to 4-in. pipe were replaced by 20 to 8-in., in Taunton, Mass., during 1895. Much of the work was in the principal streets of the city, but the domestic pressure was kept up and an adequate fire protection was maintained at 31 fires. All work was kept heavily braced where there was a chance to blow out temporary plugs. The direct pressure system is in use, and part of the work mentioned was in connection with providing a duplicate force main. A bad fire broke out while the work was in progress, with one of the 20-in. mains shut off, but the other 20-in. main was sufficient for the demands and the fire was speedily controlled. The above information has been abstracted from a paper read before the New England Water-Works Association, on Feb. 12, by Mr. Geo. F. Chace, Superintendent of the Taunton Water-Works. The paper was received by us too late to include an abstract of it in the report of the meeting given in our issue of Feb. 20.

The franchise of the Duluth Gas & Water Co. has been repealed, or at least an ordinance to that effect has been passed by the City Council and approved by the Mayor. This action appears to be due, at least in part, to the alleged impure water supply furnished by the company, and which the city is trying to prove is a cause of typhoid fever. Mr. Floyd Davis of Des Moines, Ia., has been engaged by the city to pursue still further its quest for evidence along the above line. A suit has been brought against the company for $5,000 damages on account of the death of a man from typhoid fever, on the ground that the disease was contracted from germs in the water furnished by the company. As previously stated in these columns, the manager of the company was recently indicted by the Grand Jury for manslaughter by means of impure water.

Filtration experiments on the water supply of Philadelphia are recommended by Mr. John C. Trautwine, Assoc. Am. Soc. C. E., Chief of the Philadelphia Bureau of Water, in his annual report for 1895. The tests would be made on the waters of the lower Delaware and Schuylkill rivers, close to the upper portions of the city. The Council's Committee on Water has recommended an appropriation for conducting the desired experiments. The matter has been agitated for years, and has at times gone so far as to result in the securing of bids for a permanent plant.

An epidemic of typhoid fever at Elmira, N. Y., is attributed to the pollution of the public water supply. Up to Feb. 12 there had been reported 180 cases and 15 deaths. Between Jan. 3 and 27, the number of cases was 87, of which it is said that 77 were in families using the public water supply and the balance were children attending schools where such water was supplied. It is stated that Corning, Bath, Hornellsville and other places above Elmira discharge sewage into the Chemung River, from which its water supply is drawn. Corning is said to be 17 miles above Elmira. Its population in 1890 was 8,550. An examination made by Professor Albert R. Leeds, of Hoboken, of water taken Jan. 29, showed an average of 1,080 bacteria per cu. cm. Professor Leeds reported to the Elmira Water Works Co., for whom the analyses were made, that the number and character of the bacteria indicated "some sewage contamination," and that he had found in other instances, thousands of bacteria in streams as far as 15 miles below sewer outlets. The typhoid bacillus, Professor Leeds stated, was not found. He might have added that it was not likely to be, in the present state of bacteriology.

The most serious railway accident of the week was the derailment of a snow-plow and its pushing engine, near Brockport, N. Y., on the New York Central R. R., Feb. 22. The plow was working east from Rochester, clearing the drifts, when it struck a hard, partly-frozen drift, which caused the overturning of the plow and engine. The engineman was killed and the fireman severely injured.——A passenger train on the Central Vermont R. R. was derailed near Ludlow, Vt., Feb. 18, and the baggage car, mail car and one day car went down the bank. Three persons were seriously injured.

The 365-ft. drawspan of the bridge over the Mississippi River, between Rock Island, Ill., and Davenport, Ia., was damaged by a movement of the ice Feb. 25, a portion of the falsework and three panels of the bridge in process of erection being carried away. Nobody was injured. As described in our issue of Nov. 28, 1895, a new double-track double-deck structure is being built upon the widened piers of the old bridge, the upper deck carrying the Chicago, Rock Island & Pacific Ry., and the lower deck a roadway with street car tracks. There will be eight spans including the drawspan.

Two locomotive boiler explosions have been reported during the past week. The first took place on the Delaware, Lackawanna & Western R. R. near Cassville, N. Y., on Feb. 19, killing the engineman and fireman. The train, comprising baggage and passenger cars, was running at its usual speed. The engine was torn to pieces, and the trucks left the track, the mass of broken and twisted iron toppling over into the ditch. The cars remained on the track, and no passengers were injured. The cause of the explosion is stated to have been low water. The second explosion was on Feb. 20, on a freight train on the Nashville, Chattanooga & St. Louis Ry., near Bridgeport, Ala. The engine was a Baldwin consolidation, and the explosion rent it into a thousand pieces, some of which were thrown hundreds of feet. The engineman and firemen were killed.

A boiler explosion took place at the World's Fair grounds, Chicago, on Feb. 20, injuring five men, two of them fatally.

The elbow of an 8-inch main steam pipe, at the works of the Fletcher Mfg. Co., in Providence, R. I., burst on Feb. 21.

The American Line steamship "St. Paul," lately ashore on the New Jersey coast, will resume her regular trips on Feb. 26. She was docked at Newport News and carefully examined. With the exception of slight dents in two of her keel plates, she was absolutely uninjured, and her machinery is in as good condition as when she was launched.

The new power plant for the new mill of the Warren, R. I., Manufacturing Co., is to contain a vertical compound Allis-Corliss engine, 32 ft. high, with cylinders 32 and 62 ins. diameter and 5 ft. stroke. Some years ago this company put in a quadruple expansion horizontal Allis engine, with cylinders 24, 36, 52½, and 64½ ins. diameter and 6-ft. stroke, with a 32-ft. fly wheel, running 52 revolutions per minute. The experience with the quadruple engine, according to a report in the Providence "Journal," of Feb. 10, has not been such as to warrant the company's duplicating it in the new mill. It is said that the engine was too powerful for the load, and that part of the time only two cylinders were in use. The older engine had its 32-ft. fly wheel grooved for rope-driving. The new engine has a 24-ft. wheel, 127-in. face, and will have four 3-ply belts, which indicates that belts are preferred to ropes as the result of experience. The new engine is to run at 70 revolutions per minute. The fly wheel will weigh 125,000 lbs., and the shaft will be 23 ins. in diameter.

A bill, authorizing Mr. A. C. Mather and others to build a bridge across the Niagara River, has been introduced in the New York Legislature. This bridge would have current wheels suspended from it, with a view of developing water power, and it would also be built for the use of pedestrians, vehicles of all kinds, "and other traffic" across the Niagara River. The location is to be such as is best suited to the development of water power for the city of Buffalo.

A third St. Louis bridge over the Mississippi River is wanted by the North St. Louis Improvement Association, and the people of that section of the city. The project is before Congress, but has made little progress as yet.

The proposed Montreal bridge across the St. Lawrence River is opposed by the Board of Harbor Commissioners of Montreal. The bridge would be within their jurisdiction, and they oppose the terms of the bill for incorporation proposed by the South Shore Suburban Ry. Co.

The annual report of the State Engineer, New York, Mr. Campbell W. Adams, just issued, states that 25 fully equipped parties of engineers are now in the field making the surveys preparatory to letting work on the canal improvement, under the $9,000,000 appropriation of last fall. Each corps has 18 miles of canal allotted to it, and detailed estimates of cost will probably be ready by May 1. It is expected that contracts can be awarded in June and July. Plans have been nearly completed for the steel lift lock at Lockport, intended to replace the five locks now there, and similar plans are being prepared for the replacement of the series of locks at Cohoes, Little Falls and Newark. In regard to the surveys for storage at the headwaters of the Hudson, now reported upon by Mr. George W. Rafter, M. Am. Soc. C. E., it is estimated that for an expenditure of $2,606,550 a storage capacity of 41,595,000,000 cu. ft. could be obtained, and this storage would be sufficient to increase the minimum flow at Glen's Falls to four times its present volume, and increase the low-water depth of the Hudson, at Albany, by about 18 ins.

The New Orleans drainage scheme has received a setback. The mayor has vetoed the ordinance directing the comptroller to advertise for bids for constructing the drainage works, on the ground that funds are not available to meet the cost. He states that the veto is in no way a disapproval of the plans and specifications adopted, nor made because he wishes to retard the work, which he believes to be "an absolute necessity, if we are to take our place in the category of modern American cities." To secure funds a general tax levy may be authorized by a popular vote, or legislation permitting a bond issue may be secured. The latter course is favored by the mayor. The legislature does not meet until May, and in the natural course of events some further time would elapse before the desired authority could be obtained. The mayor also states that the period proposed for advertising for bids, 30 days, was insufficient.

An architectural competition for a $1,000,000 state capitol for Montana is announced, and plans will be received up to July 1. Particulars as to prizes and conditions can be obtained by addressing the State Capitol Commission, Helena, Mont.

The heavy rains of Feb. 6 threatened so much damage to the filter beds of Mount Vernon, N. Y., described in Engineering News of Aug. 23, 1894, that the water company cut the dam of the reservoir adjoining the beds to prevent the flooding of the latter.

GAGINGS OF THE DRY WEATHER FLOW OF SEWAGE AT DES MOINES, IA.*

By J. A. Moore, Callender, Ia., and W. J. Thomas, Moingona, Ia.,

Graduates of the Class of 1895, from the Civil Engineering Department of the Iowa Agricultural College, Ames, Ia.

Need of Experiments.—Comparatively few gagings have ever been made of the actual flow of sewage. The custom has been in designing

FIG. 1.—GENERAL VIEW OF GAGING APPARATUS FOR MEASURING THE FLOW OF THE WEST SIDE OUTLET SEWER; DES MOINES, IA.

sewers to estimate the size required from the statistics of water consumption, which are usually at hand. That the consumption of water and the flow of sewage for any given district may be quite widely at variance must be admitted, and hence the value of a reliable series of gagings will be recognized at once by engineers whose duty it may be to design sewerage systems.

Staley and Pierson, in their work entitled "The Separate System of Sewerage," p. 63, say:

> Owing to the scarcity and incompleteness of data at present accessible on the actual flow of sewers and to their unreliability as well, and to the very complete records of water consumption, which are made possible by the use of pumping machinery automatically recording its own performances, an investigation and classification of the statistics of water consumption will undoubtedly be of use in designing a sewerage system.

The above statement, made by engineers of recognized ability, serves to indicate the general practice of designing sewers from statistics of water consumption. After giving data on water consumption, the above-mentioned work states, p. 74:

> Exact measurements of the flow of house sewage for any considerable length of time are not accessible, if they have ever been made, and consequently we cannot use them as a basis in determining the fluctuations in sewage flow, or the ratio of maximum to mean discharge.

Former Gagings of the Dry Weather Flow of Sewers.—To place the available data on this subject in shape for comparison and use, we present herewith a record of all former sewer gagings whose records are accessible to us, giving briefly the most important results of each, and references to the authorities from whom our information is derived.

In 1880, March 15 and 16 and 20-23, gagings were taken of the flow of sewage in the Compton Av. sewer at St. Louis, Mo., by Julius Moulton.* The population actually tributary to the sewer is not given. Reckoning from the total population (8,200) occupying the territory the minimum discharge was found to be 65 gallons, the mean 102, and the maximum 149 gallons per diem per capita.

In 1880 gagings were made of the flow in the College St. sewer at Burlington, Vt., at 15-minute intervals from 7:30 a. m. to 10:30 p. m. The district which the sewer drains contained 85 houses, 54 being connected with the sewer. The population using the sewer was 325. There were two equal maxima in the flow, one occurring at 7:45 a. m. and the other at 9 a. m. The rate of discharge in gallons per capita per diem was found to be: minimum, 65; mean, 115; maximum, 140 gallons.*

Gagings were made in 1880 of the Huron St. sewer at Milwaukee, Wis. The tributary population was 3,177, and the total population of the sewer district 4,035. The maximum rate of discharge was 120 gallons per diem per capita of tributary population, or 94 gallons per capita of total population.*

The following are the results of sewer gagings made by C. H. Latrobe, C. E., in 1881, on the main outlet sewer at Memphis, Tenn.* The total population of the sewer district was approximately 35,000, of whom perhaps 20,000 were actually using the sewers. The maximum rate of discharge was 80 gallons, and the minimum, 35 gallons per diem per capita for the total population of sewer district, or a maximum of 140 gallons and a minimum of 61 gallons per capita of tributary population. The hourly rate of flow was found to be remarkably uniform.

In the report on the sewerage of Providence there are given the results of a number of gagings, made at that place in 1884, by Samuel Gray, M. Am. Soc. C. E.* These gagings were made for 13 different sewers. The population connected ranged from 162 to 8,800, the total being 33,825. The results showed flows of sewage per capita per diem ranging from 14 to 159 gallons. The average rate of flow was 78 gallons per diem per capita. The length of time the discharge was above the average rate ranged from 41% to 83% of the total time. The sewers having the smallest population connected showed the greatest variations in the per capita rates of flow. Mr. Gray states that the sewers in the wet portions of the city gave larger rates of flow than the others. This shows that the ground water infiltration was of an appreciable amount.

In 1885, Geo. S. Pierson, C. E., made a series of weir measurements of the flow of the Water St. main sewer, at Kalamazoo, Mich. Readings were taken on Monday, March 9, from 1 a. m. to 12 midnight. The minimum discharge occurred at 3 a. m., and amounted to 224 gallons per minute. The maximum amounted to 287 gallons per minute and occurred at 4 p. m. The mean discharge for the whole 24 hours was 254 gallons per minute. Tributary population not stated.*

In the spring of 1891 gagings were made of the flow of several sewers at Toronto, Canada. The gagings extended over a period of three days and were made for 16 different sewers. The total tributary population was 168,081. The average daily flow of sewage was 87 gallons per capita per diem, ranging in the different sewers from 33 to 316 gallons per capita per diem.*

In January, 1891, the flow of the main outfall sewer of the State Insane Hospital, at Weston, W. Va., was gaged by wier measurements under the direction of Mr. Geo. W. Rafter, M. Am. Soc. C. E., for a period of 48 hours. The tributary population at the hospital was 1,000. The sewage proper was found to be 91,000 gallons per day, which for a tributary population of 1,000 amounts to 91 gallons per capita per diem. The maximum rate of flow was 151 gallons per capita per diem, and occurred between 9 and 10 a. m., while the minimum rate was 40 gallons per capita per diem and occurred between 1 and 2 a. m.*

Valuable information relating to the dry weather rate of flow in sewers is to be gained from the sewage pumping records at Atlantic City, N. J. The records were kept from Dec. 1, 1891, to Nov. 30, 1892.* The maximum rate of pumping occurred during the months of July and August, and was 93,466,000 gallons per month. The minimum was in December, and was 49,100,000 gallons per month. The average daily amount of sewage pumped was 2,173,750 gallons. The resident population was 15,000, but it is said that during July and August the total tributary population was as high as 100,000. The excess of water pumped over sewage pumped during the year ranged from 11 to 75%, the average being 45%.

In February, 1892, W. B. Landreth, M. Am. Soc. C. E., gaged the flow of the main sewer of Schenectady, N. Y., for a period of 24 hours. The greatest flow was at 10 a. m., when 5.04% of the total daily flow of about 860,000 gallons was passing through the sewer hourly. The minimum flow, 3.52%, occurred at 3 a. m.*

An interesting set of experiments were those conducted by Alva J. Grover, Assoc. M. Am. Soc. C. E., in the city of Omaha, Neb.,* for Jan., 1893. Mr. Grover gaged the velocity of flow of sewage in

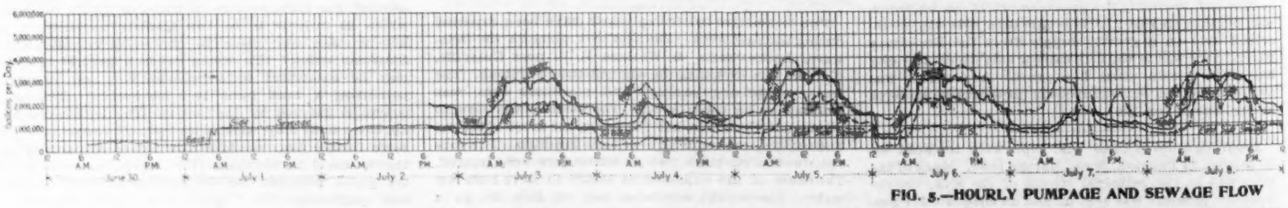


FIG. 5.—HOURLY PUMPAGE AND SEWAGE FLOW

*Awarded second prize in Engineering News Thesis Competition of 1895.

*See Engineering News, Sept. 4, 1880; also "The Separate System of Sewerage," p. 80.

*See "The Separate System of Sewerage," p. 77.

*See "The Separate System of Sewerage," p. 78.

*See his "Report to Mayor and City Council," 1881; also "The Separate System of Sewerage," p. 79.

*See "Sewage Disposal in the United States," by Rafter and Baker, p. 140.

*See "The Separate System of Sewerage," for details.

*See Engineering News for Nov. 24, 1892; also "Sewage Disposal in the United States," by Rafter and Baker, p. 144.

*See "Sewage Disposal in the United States."

*See Engineering News, Feb. 9, 1893; also "Sewage Disposal," p. 144.

*See Engineering News, March 26, 1892; also "Sewage Disposal," p. 143.

*See "Transactions of Am. Soc. of C. E.," Jan., 1893.

a sewer whose estimated tributary population was 40,000.

In 1894 Mr. J. C. Miller made a series of weir measurements of the flow of the sewer leading from the main buildings of the Iowa Agricultural College. Hourly readings were taken for one week, commencing Saturday, Sept. 15. The number of persons contributing to the flow of sewage was 289, besides 203 persons who were at the building only for their meals. The flow of sewage for the week was as follows, in gallons per 24 hours:

	Average rate.	Maximum rate.
Saturday	7,757	25,600
Sunday	8,000	20,800
Monday	9,300	17,200
Tuesday	9,700	21,300
Wednesday	9,900	19,500
Thursday	9,000	19,700
Friday	10,900	21,600

The average flow per capita per diem (leaving out of account the day boarders) was about 32 gallons, while the maximum was about 77 gallons. The maximum rate of flow occurred at different times, betwen 9 a. m. and 5 p. m. Practically all of the flow occurred between the hours of 6 a. m. and 10 p. m. It almost entirely ceased for a few hours at night. The water consumption during this week averaged 37½ gallons per capita per diem.

With the purpose of adding a small amount to the information on this subject the writers have made a series of gagings of the two principal outfall sewers of the city of Des Moines. The gaging commenced June 30 and ended July 16, 1895. The end in view was to gage the dry weather flow, and no attempt was made to determine storm water flow.

Description of Sewer System of Des Moines.—The sewers of the city of Des Moines are designed to carry both storm water and sanitary sewage. The city is built on both banks of the Des Moines River. Each side of the river has its own sewerage system. The population on the west side is, according to the census of 1895, about 34,200; that on the east side, 21,900; the total population of the city being 56,110. The city has quite a number of factories, mostly located in the southern part of the east side.

A 60-in. brick intercepting sewer on the west side empties into the Raccoon River, within a few yards of its junction with the Des Moines. On the east side a 48-in. brick intercepting sewer empties into the Des Moines at a point almost directly opposite the mouth of the Raccoon. These intercepting sewers extend north nearly parallel with the river through the main business portion of the city. The business portion of the city is built upon comparatively level ground near the river, mainly on the west side. The residence portion extends back upon the river bluffs, which rise to a height of perhaps 175 ft. above the river. On the west side three large branch sewers extend north and west along valleys passing through the residence portion of the city. Laterals enter these from all the principal streets.

The east side has two distinct systems. The portion of the city east of a ridge which extends north and south at about East 12th St. is drained by laterals which flow into a collecting sewer which extends north and south on East 18th St., and empties into the Des Moines River at the foot of that street. This system is not very extensively used, the main contributors to its flow being a few factories and packing houses, and it was not gaged.

About 57.2 miles of sewers had been constructed up to Jan. 1, 1895, as shown by the report of City Engineer Frank Pelton for 1894. All sewers of 36 ins. and over are brick; all others pipe. The original plan was to construct storm water overflow conduits emptying into the water courses wherever possible; the object being to relieve the sewers in case of engorgement by heavy rains. This plan has not been strictly adhered to by all the city engineers. The following figures have been taken from the report of the City Engineer Jan. 1, 1895.

West Side system (figures given in round numbers):

Number of feet specified as brick sewers	49,000
" " " " pipe "	155,000
" " " not specified	31,000
Total	235,000
East Side system, west of 12th St. divide:	
Number of feet specified as brick sewers	5,000
" " " " pipe "	17,000
" " " not specified	7,000
Total	29,000
East Side system, east of 12th St. divide:	
Number of feet specified as brick sewers	5,000
" " " pipe "	25,000
" " " not specified	8,000
Total	38,000

Considerable difficulty was experienced in estimating the population tributary to each of the above systems, notwithstanding the fact that a census of the city was in progress when the gagings were made, and has been completed since. This difficulty has arisen from the fact that the city records of house connections are very incomplete. As a result of this fact the estimates of tributary population given below are to be considered as only approximately correct. They were made in the following manner:

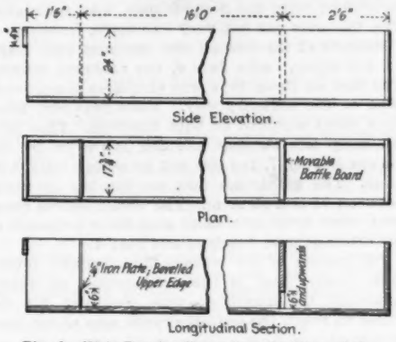


Fig. 2.—Weir Box for Measuring the Flow of the West Side Outlet Sewer; Des Moines, Ia.

The recent census of the city was taken by wards. The city is also divided into assessors' districts. The ward lines usually run north and south through the city, thereby dividing the city into comparatively narrow strips of territory; while the assessors' districts are more nearly square. A ward includes parts of from two to five assessors' districts. The number of inhabitants of the part of the ward lying in each assessor's district is given. A map showing the location of the sewers and water mains and the boundaries of the wards and the assessors' districts was drawn.

The city being thus divided up into sections (whose populations ranged from 158 to 8,157) an estimate of the percentage of population in each section using the sewers of the two systems gaged was made. We estimate that a total of 19,400 people are using the sewers of the west side system, and 8,100 using those on the east side gaged. This estimate has been carefully revised and corrected by Mr. G. W. Kemp, Sewer Inspector for the city. Mr. Kemp has an intimate knowledge of all parts of the city and the sewer system, and is probably better fitted than any other man for making this estimate.

Of the total population of the city, 56,110, 17,000 are certainly out of the district of the sewers gaged; 8,200 of this number being on the west side and 8,800 on the east side. This would make the total population within the west side sewer district 26,000, of whom 19,400 are directly tributary to the sewers; while on the east side the figures for the sewer gaged would be 13,100 people within the district, of whom 8,100 use the sewers.

Water Supply System of Des Moines.—Realizing the importance of the study of water consumption in connection with the flow of sewage, we present data giving the consumption of water by the city during the time of the experiments.

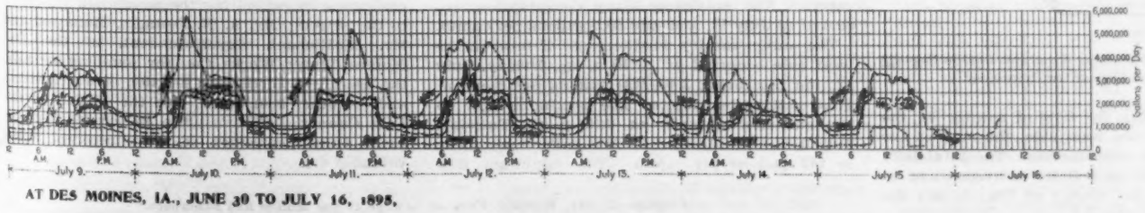
The city is supplied with water by the Des Moines Water-Works Co. The supply is derived from filter galleries which extend out under the Raccoon River. The pumping station is located at West 16th and Walnut Sts. The length of mains laid up to Jan. 1, 1895, was 79.75 miles. The water is distributed by direct pressure. There is a large stand-pipe built on the bluffs about 175 ft. above the river.

Through the courtesy of Mr. A. N. Denman, Manager, and Mr. McMichael, Superintendent of the water-works company, we were furnished with the pumping counter readings for each hour throughout the period of twelve days, during which our experiments were in progress. The plunger displacement and number of revolutions of the engine enabled us to calculate the amount of water pumped. These results have been placed on the same sheets as the sewage flow curves, thereby permitting an interesting comparison between the water consumption and the flow of sewage.

In estimating the population supplied by the pumps the same difficulty was met as in estimating the population tributary to the sewers, and it was necessary to resort to the same expedient. The estimate by sections showed that the probable population supplied was 33,700. We estimate that 13,200 people are out of the limit of the company's mains, leaving about 43,400 within those limits. The estimate on population supplied was revised by Mr. McMichael, who has been employed by the water company for the past 20 years as Engineer and Superintendent of Construction, and is familiar with the entire system. The average daily amount of water pumped during the time of the experiments was about 2,500,000 gallons, giving the average consumption per capita per diem of population supplied as about 74 gallons. The number of gallons of water pumped for the different days was as follows:

Thursday,	July	4	1,829,000
Friday,	"	5	2,352,635
Saturday,	"	6	2,750,205
Sunday,	"	7	1,809,110
Monday,	"	8	2,379,820
Tuesday,	"	9	2,437,825
Wednesday,	"	10	2,694,460
Thursday,	"	11	2,805,620
Friday,	"	12	3,071,640
Saturday,	"	13	3,094,000
Sunday,	"	14	2,279,000

Most water consumers are supplied through meters, and hence the waste is probably reduced to the minimum. There are about 15 hydraulic elevators on the west side and three on the east side.



AT DES MOINES, IA., JUNE 30 TO JULY 16, 1895.

Apparatus and Calculations.—After quite an extensive study of ways and means for making sewer gagings, it was decided in this case to obtain continuous automatic records of the depth of flow over weirs in wooden troughs. A general view of the gaging apparatus used at the west side sewer is shown by Fig. 1, and the details of the weir box at this station is shown by Fig. 2. The east side weir box was 10 ft. long and

1½ ft. high, but otherwise its dimensions were those given in Fig. 2. The recording apparatus is shown by Fig. 3. The plan of the troughs and method of calculating results are the same as those used by M. Bazin in France in 1888.* The curve of flow was traced upon a paper placed on the cylinder shown by Fig. 3. A fresh paper was supplied every twelve hours, that being the length of time required for one revolution of the cylinder. Each time a new paper was placed on the cylinder the height of water above the weir was determined by measurements and a zero reading established on the paper. Two such points were established, one on each side of the paper, and the straight line joining them taken as the base line. The length of the ordinates from the straight line to the curve of flow was determined for each 15 minutes.

The number of gallons of flow for each 15 minutes was determined by Bazin's formula. The formula is

$$Q = \tfrac{2}{3}\, w' \left[1 + 0.55\left(\frac{h_2}{p + h_2}\right)^2\right] b\, h_2 \sqrt{2\,g\,h}$$

in which w' is the coefficient of discharge and has a value given by the formula

$$w' = 0.6075 + \frac{.0148}{h_2\ (\text{in ft.})},$$

Q = flow of cu. ft. per sec.
h = height of water over weir, b = width of weir and p = height of weir from bottom of trough, all in feet.
g = 32.2 ft. per sec.

General Discussion of Results.—To enable the results of the gagings to be more readily seen curves have been plotted showing side by side

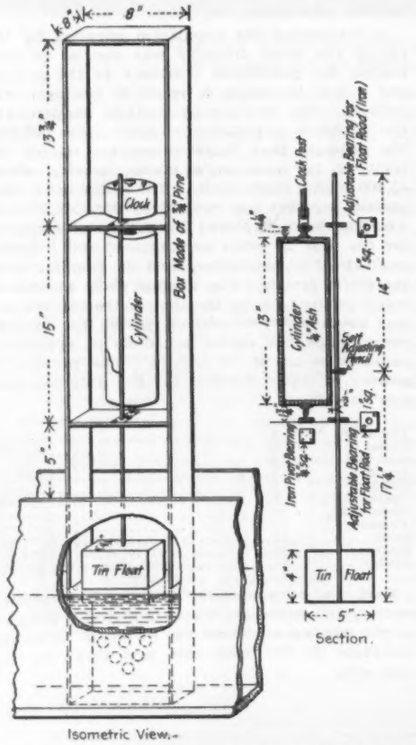


Fig. 3.—Details of Recording Apparatus used in Gaging Sewage Flow at Des Moines, Ia.

throughout each day the flow of sewage on the east side, that on the west side, the sum of the two, and the water consumption. The total daily amounts of sewage and water corresponding to the above curves are shown by Fig. 4, and the hourly amounts by Fig. 5.*

A study of these plates brings out many interesting facts. For example, the effect of the noon hour stop of factories, etc., is plainly shown on the curves of flow on the west side. The same thing was noticed on the Omaha gagings. The main business portion of the city is tributary to the west side system, and the marked increase of flow during business hours is plainly brought out. Hydraulic elevators and water motors augment the flow to a considerable extent during this time. Most of these, however, are in operation only a small part of the time.

The flow of sewage on the east side rises rapidly about 5 a. m. After this rapid rise the flow is quite constant till about 11 or 12 p. m., when it falls rapidly and continues low till 5 a. m. The minimum occurs about 3 a. m.; the maximum may occur at any time during the business part of the day. It will be noticed that during the last few days of the gagings (with the exception of a few hours during the middle of the day, July 15) the flow on this side ruled very low all the time. About this time we discovered that sewage was flowing from the storm water overflow conduit which empties into the river at the foot of East Grand Ave. It is probable that the sewer became dammed up and caused an overflow into this channel. The factory district is located in this part of the city and the flow from these, particularly that from the Soap Works, was noticeable. The factories are not very extensive, however.

Records of the flow on two Sundays, July 7 and 14, are given. Also July 4, the national holiday. The flow on these days was of course much below that of the ordinary day. Unfortunately, however, rains occurred on both Sundays. That people sleep late Sunday morning is shown by the curves of July 7, the rise not occurring until 8:30 a. m. The maximum flow on Sunday occurred between 11 and 12 a. m. The water curves show that some lawn sprinkling may have occurred in the afternoons of Sundays and July 4.

The curves of the sewage flow usually follow quite closely that of the consumption of water. Evidently the length of time required for the water to reach the outfall sewers was about one-half hour.

On July 10, 11 and 13, it will be noticed, the curves of water pumped are very high at certain hours, and that this surplus of water pumped did not affect the sewage. The explanation is that the company was flushing out "dead ends" in the district tributary to the system east of the East 12th St. divide.

On the east side for the week beginning with Wednesday, July 3, the average daily sewage flow per capita throughout the week is found to be 74 gallons; on the west side for the week beginning Friday, July 5, the average daily per capita sewage flow is found to be only 66 gallons. The difference is probably due to the fact that more factory sewage enters the east side sewers than the west side sewers.

For the week taken on the east side, the maximum daily flow occurred on Wednesday, July 3, and was 105 gallons per capita. The minimum flow occurred on Sunday, July 7, and amounted to 29 gallons per capita.

On the west side, for the week taken, the maximum average daily flow occurred on Friday, July 5, and was 73 gallons, while the minimum occurred on Sunday, July 7, and was 47 gallons per capita.

The daily water consumption for the week beginning Friday, July 5, averaged 73.5 gallons per capita. The maximum daily consumption occurred on July 11, and was 80.3 gallons per capita.

The maximum dry weather rate of flow on the west side occurred at 10:15 a. m., Friday, July 12, the rate being 3,400,000 gallons per diem, or 175.3 gallons per capita. The maximum flow on the east side occurred at 6:30 p. m., Tuesday, July 2, the rate being 1,150,000 gallons per diem, or 142 gallons per capita. The minimum flow on the east side occurred at 4:30 a. m., July 5, and was at the rate of 182,304 gallons per diem, or 22.5 gallons per capita. The minimum flow on the west side occurred at 4 a. m., July 5, and was at the rate of 451,968 gallons per diem, or 23.2 gallons per capita.

In order to summarize the results of previous gagings for inspection and comparison we present the accompanying table.

It will be noticed that our average results are considerably lower than most of those given in the above table; this is probably due to the extensive use of water meters in Des Moines and the probable consequent reduction of waste water to the minimum. The fact that in spite of this the maximum per capita flow on the west side is higher than in any of the other cases in the table would indicate that the other gagings may not have been continued long enough to show the real maximum. We believe our results are applicable to well metered western cities of a population of 40,000 to 70,000 inhabitants.

The results are, of course, of most value in designing sewers of the separate system. An examination of the table would indicate that in most cases separate sewers should be designed to carry maximum flows of from 150 to 175 gallons per capita per diem, and that sewage disposal works,

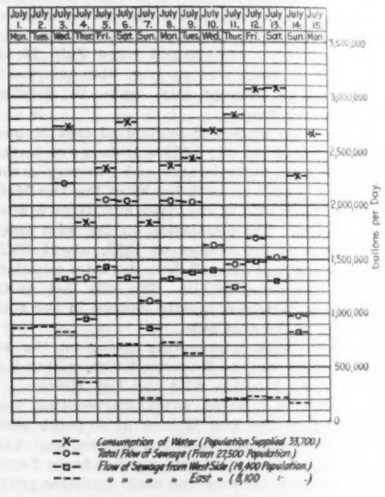


Fig. 4.—Daily Water Pumpage and Sewage Flow at Des Moines, Ia., July 1 to July 15, 1895.

when separate sewers are used, will generally have to purify from 65 to 100 gallons per capita per diem.

The work herein described was done under the direction of Professor A. Marston, of the Civil Engineering Department of the Iowa Agricultural College. The Department bore part of the expense of constructing the apparatus.

We wish to thank the City Engineer of Des Moines, Mr. Frank Pelton, for the use of maps, and for other courtesies; Mr. G. W. Kemp for his assistance in estimating the population tributary to the sewers; Mr. A. N. Denman, Manager, and Mr. McMichael, Superintendent, of the Des Moines Water-Works Co., for pumping records, the use of maps showing location of water mains and for other assistance; also the officials of the Polk County Auditor's office for census reports. From these gentlemen we have received much valuable aid.

Gagings of Dry Weather Flow of Sewage at Des Moines and Elsewhere.*

Sewer.	Date.	—Population— Total.	Tributary.	—Sewage Flow.— Minimum.	Average.	Maximum.
Comptor Ave., St. Louis	1880	8,200	....	65	102	140
College St., Burlington, Vt.	1880	.....	325	65	115	140
Huron St., Milwaukee, Wis.	1880	4,030	3,174	..	..	120
Memphis, Tenn.	1881	3,500	20,000	61	..	140
13 Sewers, Providence, R. I.	1884	.....	33,825	..	78	..
16 Sewers, Toronto, Can.	1891	.....	168,081	..	87	..
Insane Hospital, Weston, W. Va.	1891	.....	1,000	40	91	151
Main Building, Iowa Agricultural College	1894	.....	289	0	32	77
Des Moines, Iowa, east side	1895	13,100	3,100	22.5	74	142
Des Moines, Iowa, west side	1895	26,000	19,400	23.2	66	175.3

*The rates of flow given are based on tributary population where this is given.

*See Church's "Mechanics," p. 688, Art. 506a.

*The originals showed a diagram for each day. For convenience and compactness a continuous diagram has been plotted for the hourly flows.—Ed.

AN ORDINANCE TO PREVENT ELECTROLYSIS OF WATER AND GAS PIPES AT RICHMOND, VA.

The first city to pass an ordinance designed to prevent the electrolysis of gas and water mains, so far as we know, is Richmond, Va., where such an ordinance was approved by the Mayor on Jan. 23, 1896. We reprint the ordinance in full for the benefit of other cities having the same problem before them.

Be it ordained by the Council of the city of Richmond:

(1) That each and every street railway company in the city of Richmond, now incorporated or hereafter chartered, shall obey and fully comply with each and every regulation, rule or requirement herein contained. Such requirements, rules or regulations are to be amendments to all ordinances authorizing any street railway to use electricity as a motive power on the streets of said city:

The rail on any street railway shall be a continuous rail electrically welded at the joints, or if separated or distinct rails are used, they shall be bonded or connected at the rail joints, as shown by the following requirements: For all rails weighing from 10 to 60 lbs. per yd. there shall be one bond of No. 0000 B. W. G. copper wire at each joint. For all rails weighing from 60 to 90 lbs. per yd., there shall be two bonds of No. 0000 B. W. G. copper wire. Where the copper wire is joined to the rails, the holes through the rails shall be carefully drilled and the No. 0000 copper wire made to carefully fit the hole, a thread shall be cut in the end of the wire and a copper nut or a copper washer with iron nut shall be used, and the surface of the rail so smoothed or dressed that when the nut is made tight there shall be thorough contact with the rail. The contact of the wire with the rail to be made on bright surfaces, and the end of the copper wire to be enlarged so as to have no less than ten times the area of the bonding wire in contact with the bright surfaces on the sides and hole of the rail, and with a close fit in the hole of the rail, so as to make a waterproof joint. Immediately after the bonds are put in, as above specified, the whole shall be thoroughly painted with the best electrical insulating paint.

(2) At every third rail the track shall be "cross-bonded," No. 0 copper wire, B. and S. gage; connection is to be made to the loop of the nearest bond with a wrapped joint and soldered. On double track construction both tracks shall be connected together in the manner as above specified.

(3) In addition to the above, a continuous supplemental wire shall be laid in the center of each track and connected to each rail at least every 300 ft., extending the whole length of the road from the power-house and connected to the negative "bus bar" of the generators. The size of the wire shall be equal in area to that of all the feed wires that supply power over the section, allowance being made for the bond wires. No wire less than a No. 0 B. and S. gage to be used. In all cases the rails are to be connected to the negative bus bar of the generators.

(4) When the current is returned from the track or rails to the power stations there shall be provided and maintained a metallic return of old rails bonded together by copper wire or some similar metallic return of ample and sufficient area properly put down. Under no condition shall the current be grounded by means of wires or rods at any point near the gas or water mains or the iron or lead pipe connections. Wherever or whenever it is shown by either a volt or ampere-meter that there is any flow of electric current from the gas or water mains to the rails or along these mains, it shall be deemed sufficient proof that the said mains or pipes are liable to electric corrosion, and upon notice of the superintendent of the gas or of the water department, or their authorized subordinates, that there is such a flow, the company causing or producing the same shall at once take proper steps to prevent the electric current from reaching the main. For each and every day the company in fault shall, after receipt of said notice, fail to properly prevent the flow of the electric current as complained of, the said company shall be liable to a fine of not less than $25 nor more than $500; each day's failure to be a separate offence. Each company having an electric railway already constructed shall proceed within one month from the approval of this ordinance to obey and carry out each and every requirement, rule or regulation set forth in the first four sections of this ordinance, and shall within six months from said approval fully comply with each and every such requirement, rule or regulation unless the method of bonding the rails as now in use by the electric railroads prove to the superintendents of the gas and water departments, by tests, that no electric current is being carried to or along the gas and water mains; then the said company using such method of bonding and construction will not be liable to the requirements as to bonding its rails as set forth in this ordinance. For any failure to obey the requirements or provisions of this section, the company so failing shall be liable to a fine of not less than $25 nor more than $500, for each day's failure to be a separate offence.

(5) Wherever and whenever any electric street railway company in this city shall use and adopt the double trolley system or any other system which does not use the rails or the ground for the return current to the power-house, then in such case the requirements set forth in this ordinance will not be enforced.

(6) All work to be done in the very best manner by experienced workmen. Before commencing work the superintendent of the street railway shall submit to the superintendent of the water-works samples of all materials and appliances that they propose to use, and if the same meet with his approval, he shall issue a permit allowing the work to proceed. The whole work shall at all times be subject to the inspection of the superintendents of the water and gas works, and if they shall find that the work is not being done in accordance with this ordinance, then they or either of them shall have authority to stop the work until this ordinance and its requirements are complied with. Any company causing any damage, injury or destruction of or to any water or gas main or to their respective connections by electric corrosion or electrolysis shall be liable for and pay to the city of Richmond, through its treasurer, all expenses and costs incurred by the city through either of said departments in repairing or replacing any such main or connection. Bills for such repairing or replacing shall be presented to the company by the superintendent (or his authorized subordinate) of the department doing the repairing or replacing, and if not paid in 30 days from date of presentment shall be put in the hands of the City Attorney for collection by suit if necessary.

Ben. T. August, City Clerk.

THE MOBILITY OF MOLECULES OF CAST IRON.*

By Alex. E. Outerbridge, Jr.**

It has been generally accepted as a fact that cast iron under the influence of repeated shocks becomes brittle, and will finally break under a blow which otherwise it would have withstood.

It will probably surprize metallurgists, therefore, to learn that experiment disproves the supposed fact and establishes exactly the opposite condition.

The result of about a thousand tests of bars of cast iron of all grades, from the softest foundry mixtures to the strongest car-wheel metal, enables me to state with confidence that within limits cast iron is materially strengthened by subjection to shocks or repeated blows.

It is very well known that the usual process of annealing castings—such, for example, as car-wheels—increases their strength by releasing cooling strains.

It is not well known, if known at all—prior to this announcement—that the molecules of cast iron are capable of movement (for they do not touch each other†) without the necessity of heating the castings, and they can thus re-arrange themselves in comfortable relation to their neighbors, and relieve the over-crowding near the surface of the casting, or, in more technical words, a molecular annealing may be accomplished at ordinary temperatures which will release the strains in the castings, precisely as does annealing by slow cooling in heated pits or ovens. Such a surprising statement should not be made without sufficient data to establish its correctness beyond cavil, since it is contrary to former belief, certain to be questioned and properly so.

Before proceeding to give a record of the experiments which have been made and which can be readily repeated by any one, a brief history of the origin of the first observation leading thereto may be interesting.

I noticed in the year 1883 (being at that time engaged in metallurgical work at a large car-wheel establishment), that chilled cast iron car-wheels rarely cracked in ordinary sevice after having been used for any considerable time; if wheels did not crack when comparatively new they usually lasted until worn out or condemned for other causes. No application was made of this observation at that time further than to institute a careful investigation of the condition of the annealing ovens when some new wheels were returned cracked, under the supposition that the wheels were not well annealed, and an equally careful revision of the iron mixture to ascertain whether the fault lay therein.

In 1894 a large number of "transverse test bars" (1 in. square, 15 ins. long) accumulated in the foundry of Wm. Sellers & Co., Incorporated, and to expedite the cleaning of sand from their surfaces, they were all thrown into an ordinary "tumbling barrel," with other castings, and knocked about for several hours. When these test bars were broken upon the transverse testing machine and the records tabulated, I noticed, with surprise, that the average strength of the entire series was considerably higher than was usual with similar iron mixtures.

This difference was fortunately sufficiently marked to cause a careful inquiry, first into the condition of the testing machine, then as to the chemical composition of the metal in the bars, the machine was found in good order, the metal was normal. A card pattern was then made upon which twelve test bars could be molded side by side in one flask and poured from one runner.

Six of these bars were placed in the tumbling barrel and the other six were cleaned of adhering sand, with an ordinary wire brush; the twelve bars were broken upon the machine. ALL OF THE BARS WHICH HAD BEEN SUBJECTED FOR ABOUT FOUR HOURS TO INCESSANT BLOWS IN THE TUMBLING BARREL WERE STRONGER THAN THE COMPANION BARS, the actual gain varying from 10 to 15%; this metal was soft foundry iron.

These tests were repeated on several consecutive days, with similar results, while various theories were being suggested and clues "run out" to detect the hidden cause of this strange fact.

One plausible explanation offered was that the rubbing of the bars together in the tumbling barrel slightly rounded the corners and thus prevented a starting point for a "check" or break of the bar under the strain in the testing machine.

This theory was soon overthrown by tests; the corners of six bars were rounded by filing, the companion bars were not filed, all of the bars were cleaned with a wire brush and broken upon the transverse testing machine; there was no apparent gain in strength in the bars with rounded edges.

Round test bars (1¼ ins. diameter, 15 ins. long), were then poured from one ladle of iron, some of these were cleaned in the tumbling barrel and all that were so treated proved to be much stronger than the companion bars which were merely cleaned with a wire brush.

This process of eliminating false theories was continued until finally a new explanation occurred to me and simultaneously a convincing test of its accuracy suggested itself.

The explanation is indicated in the title of this paper, viz.: "The Mobility of Molecules of Cast Iron" at ordinary temperature when subjected to repeated shocks.

The crucial test referred to was in subjecting six bars to 3,000 taps each, with a hand hammer, upon one end only of each bar. All of these bars so treated showed a gain in strength equivalent to the gain exhibited by bars which had been subjected to blows over the entire surface for several hours in the tumbling barrel.

Here was a new revelation of scientific interest to the metallurgist, and, suggesting to the founder the possibility of annealing castings at ordinary temperature by availing himself of this molecular mobility, it also proves that he has for many years been unconsciously accomplishing this beneficial result—at least partially and irregularly—by tumbling small castings in a revolving barrel merely for the purpose of conveniently cleaning them from adhering sand.

Another interesting fact is incidentally brought out in this investigation, viz., that the strain caused by cooling, and consequent weakening, exists even in the smallest castings where we would naturally expect that the cooling would be practically uniform throughout the section; also that even in bars of uniform section, such as 1-in. test bars, the weakening by cooling strains sometimes amounts to more than 10% of the ultimate stress.

Repeated tests show that ½-in. bars in which the fracture is comparatively uniform to the eye throughout the section are subject to the same law.

Other tests show that the comparative difference in transverse strength between bars which have been hammered on their ends, or otherwise subjected to the process of molecular annealing by vibration when cold, and companion bars cast in the same flask not so improved depends to a certain extent upon the number and force of the blows, and to a still greater degree upon the grade of cast iron tested, for example:

1. Greater relative difference is found in hard mixtures (or strong iron) than in soft mixtures or weak iron.

2. Greater relative difference is found in 1-in. bars than in ½-in. bars, and somewhat greater difference in 2-in. bars than in 1-in. bars.

Impact Tests.

The foregoing achievements having been repeated sufficiently often to satisfy me of their absolute reliability (and really remarkable uniformity), a new series of tests was commenced for the purpose of ascertaining how many blows were required and approximately what force was needed to accomplish the desired object of relieving cooling strains. A new machine was constructed for this purpose, and light was soon thrown upon these questions, while still other important questions were suggested and answered by the use of the same machine.

The impact machine at first used was an old one, and consisted of a weight fastened to an arm swinging in a graduated arc. The friction of the pivot and the crude construction of the machine precluded certain or even approximately sure results as to the force of the blow delivered.

The new machine consisted of a frame or yoke marked in inches and a wedge-shaped weight adapted to the size of the bars to be tested, which was raised perpendicularly to any desired number of inches, and when released fell

*A paper read at the Pittsburg meeting of the American Institute of Mining Engineers, Feb. 20, 1896.

**Chemist to William Sellers & Co., Incorporated, Philadelphia, Pa.

†In order to comprehend the modern ideas of the nature of matter, we should try to realize that the molecules composing even the most dense solid substances with which we are familiar—such as gold, platinum, etc.—are not in contact and are free to move within certain well-defined limits. Lecture on "Matter," Journ. Franklin Inst., Sept., 1885, v. 90, p. 184.

by gravity in free space, striking the bars in the center between the supports, which were 12 ins. apart. A 14-lb. weight was adopted for testing 1-in. bars.

Impact testing machines have long been used, and car-wheels are accepted or condemned upon tests made upon such machines. It has always been maintained that each blow of the "drop" weakened the casting, and the final blow was only a record of the residual cohesion remaining in the metal after previous blows had proportionately weakened it.

In the case of a thoroughly annealed car-wheel this reasoning may be sufficiently correct, but as applied to impact testing machines used for testing unannealed bars the argument is absolutely fallacious. The impact testing machine is itself a means of molecularly annealing test bars; as I will now proceed to demonstrate.

Impact Experiments.

Six of the 1 in. square test bars, cleaned with the wire brush, were broken upon the impact machine by dropping the weight from a sufficient height to break each bar at the first blow; the six companion bars, also cleaned with the brush, were then in turn subjected to blows numbering from 10 to 50 each, of the same drop weight, falling one-half the former distance, these blows being insufficient to break the bars. The weight was then permitted to fall upon each of these bars, in turn, from the height at which the six bars previously tested were broken on first blow. Not one bar broke. Two, three, six, ten, and in one case fifteen blows of the same drop, from the same extreme height, were required to break these bars. In another similar case, the weight was dropped once from the former maximum height, then raised by inches until four more blows, each being 1 in. higher than the last, were delivered before breaking the piece. Subsequent tests gave still greater gains in strength.

The next experiment with the impact machine was designed to test molecularly annealed bars from the tumbling barrel, in comparison with untreated companion bars, under one heavy blow. It was found that a blow of sufficient force to break the unannealed bars with one fall of the weight must be repeated from five to twenty times (depending mainly upon the nature of the iron mixture), to break the molecularly annealed companion bars.

By careful experiment, in the manner previously noted, the ultimate strength of the bars which had not been through the tumbling barrel could be increased by successive slight blows upon the impact machine, to an equality with their companions.

The experiments here related in a running conversational narrative form a part of the daily records of metallurgical work at the foundry of Wm. Sellers & Co., incorporated, Philadelphia, and the aggregate number tabulated is very large indeed. All of the tests corroborate to the fullest degree the statements made, and they are susceptible of repetition and confirmation by any one interested in work of this character. They form part of a long series of investigations (extending over a period of 15 years), upon "the relation between the physical nature and chemical composition of cast iron." They have served to throw some light upon hitherto obscure phenomena in the design, construction, etc., of castings, and, as it is believed that they contain the germ of a new scientific discovery valuable in its principle to all workers in these fields, these brief notes are presented to the Institute of Mining Engineers in response to the invitation of its secretary, and through the courtesy of the firm of Wm. Sellers & Co., for whose benefit and at whose cost they were primarily made.

In conclusion, it should perhaps be stated, to avoid the possibility of misunderstanding, that molecular annealing of cold cast iron by successive sclight shocks differs from annealing by heat, in that it has no power to change the condition of carbon in the casting or to alter the chemical constitution in any way; all that is claimed is that every iron casting when first made is under a condition of strain, due to difference in the rate of cooling of the metal near the surface and that nearer the center, and also to difference of section; that it is possible, and practicable, to relieve these strains by tapping repeatedly the casting, thus permitting the individual metallic particles to rearrange themselves, and assume a new condition of molecular equilibrium.

The large number of tests made and the remarkable uniformity of results obtained permits me to make these statements with full confidence that their repetition, even under less favorable conditions for accurate observation than I have enjoyed, will serve to convince others of their correctness, and perhaps to establish a new law of physics of cast iron.

A few practical deductions of universal application may be drawn from these observations.

1st. Castings, such as hammer frames, housings for rolls, cast iron mortars or guns, which are to be subjected to severe blows or strains in actual use, should never be suddenly tested to anything approaching the severity of intended service.

Quantitative tests made upon the impact machine prove that the molecules of cast iron rearrange themselves under reasonably few shocks, so that it is perfectly practicable to molecularly anneal such castings when cold. Pulleys, and indeed all castings, are subjected in every day service to this process of molecular annealing, and old castings are, therefore, more reliable than new ones, unless misused.

It is not impossible that the same law applies to steel castings and, perhaps, to all metal castings, and in testing new guns each preliminary small charge of explosive material, subjecting the castings to comparatively moderate shocks, enables the gun to relieve itself of internal strains and eventually to withstand with safety shocks which would have destroyed it without this precautionary measure. This, however, is mere theory and must not carry the weight of the arguments regarding cast iron, which are clinched by a thousand actual tests.

2d. Strong iron castings and castings of irregular section have greater initial strains than soft iron castings or castings of comparatively uniform section, and it is, therefore, more important to subject such castings to gradually increasing shocks, until the strains are relieved by the movement and rearrangement of the molecules.

The tables appended hereto show the results of tests for transverse strength of test bars of different sections and widely different grades of iron which have been subjected to this process of molecular annealing, and also tests made upon the Impact Machine with test bars cast in the same molds.

Desiring to avoid unnecessary duplication of figures, a few individual tests only are here tabulated; but they represent the average of probably a thousand records.

The largest apparent gain, shown in the first table, in transverse strength, of companion bars of 1-in. section, is 525 lbs. (see last line), or very nearly 19%.

It is evident even without plotting all the tests that they would show a gradually ascending curve having direct relation, first, to the character of the alloy of iron, second to the number of blows given, up to the point when strain is relieved, beyond which an increased number of blows does not increase the strength of the bar. Furthermore, it may be noted that the tests with the impact machine prove the existence of a similar law in relation to the ability to resist sudden and severe shocks.

Similar observations apply to the tests recorded of ½-in. and 2-in. bars. All of the 2-in. bars were broken upon the testing machine of Messrs. A. Whitney & Sons by their operator, who was at first ignorant of the object of the tests. Subsequently similar tests were made by that firm with their car-wheel iron and identical results were obtained by them.

Other experiments have suggested themselves in the course of this investigation, and my paper, therefore, is not presented as an exhaustive, but as a tentative treatment of this interesting and, I believe, novel line of research, which is not devoid even in its present stage of some practical application.

TABLE I.—Strength and Elasticity of Test Bars (A) of Various Kinds of Cast Iron, Unannealed and Cleaned only with a Wire Brush, and (B) Similar Bars, Molecularly Annealed by Repeated Shocks in a Tumbling Barrel or by Tapping with a Light Hammer.

A Cleaned with a wire brush. Results from bars unannealed.		B Results from companion bars "molecularly annealed."		Remarks
Breaking strain.	Deflection.	Breaking strain.	Deflection.	
Lbs.	Ins.	Lbs.	In.	
2,350	.13	2,850	.14	Close grain iron.
2,025	.12	2,300	.14	Open " "
2,125	.13	2,275	.14	" " "
2,275	.13	2,400	.14	" " "
2,525	.14	2,850	.15	Close " "
2,175	.13	2,500	.15	Open " "
2,100	.13	2,375	.14	" " "
2,025	.12	2,300	.14	" " "
2,775	.14	2,900	.15	Close " "
2,150	.13	2,250	.13	Hammered on end of bar.
2,550	.14	2,925	.15	" " " " "
3,000	..	3,200	..	Round bars 1¼ in. diam.
3,000	..	3,150	..	Hammered on end of bar.
2,150	..	2,450	..	Round bars 1¼ in. diam.
2,100	.13	2,425	.15	Open grain iron.
2,100	..	2,400	..	Round bars 1¼ in. diam.
2,050	.12	2,400	.14	Open grain iron.
2,875	.14	3,100	.15	Close " "
2,175	.13	2,500	.15	Open " "
2,150	.13	2,350	.14	" " "
2,675	.13	3,000	.14	Close " "
2,775	.14	3,300	.15	" " "

TABLE II.—Results of Tests with Impact Testing Machine of Cast-Iron Bars. (Bars marked A cleaned with a wire brush. Bars marked B "molecularly annealed.") (Weight of drop, 14 lbs.)

		Fracture.
A....	1 drop of 13 ins. broke the bar.	Open Grain
B....	8 drops " 13 " " " "	" "
A....	2 " " 14 " " " "	" "
B....	9 " " 14 " " " "	" "
A....	2 " " 14 " " " "	" "
B....	14 " " 14 " " " "	" "
A....	2 " " 15 " " " "	" "
B....	15 " " 15 " " " "	" "
A....	3 " " 15 " " " "	" "
B....	8 " " 15 " " " "	" "
A....	2 " " 15 " " " "	" "
B....	7 " " 15 " " " "	" "
A....	3 " " 13 " " " "	Close "
B....	4 " " 15 " " " "	" "
A....	2 " " 13 " " " "	" "
B....	10 drops of 13 ins., 5 of 15 ins., 5 of 17 ins., 3 of 18 ins., broke the bar.....	" "
A....	1 drop of 14 ins. broke the bar.....	Open "
B....	20 drops of 13 ins. and 3 of 14 ins. broke the bar	" "
A....	3 drops of 13 ins. broke the bar.....	Close "
B....	15 " " 14 " " " "	" "
A....	8 " " 12 " " " "	" "
B....	50 drops of 12 ins. and 10 drops of 15 ins. failed to break the bar.	

NOTE.—The last bar, after withstanding these blows, was broken upon the transverse testing machine at a strain of 2,975 lbs.

TABLE III.—Results of Test of 2-in. Cast-Iron Bars upon A. Whitney & Son's Testing Machine. (Bars marked A cleaned with a wire brush. Bars marked B molecularly annealed.)

	Breaking strain, lbs.	Grade of iron
A.....	20,400	Close grain
B.....	21,600	" "
A.....	13,600	Open "
B.....	15,800	" "
A.....	14,000	" "
B.....	14,800	" "

THE FIRST RAILWAY IN CHINA.

In a recent consular report, Mr. Sheridan P. Read, U. S. Consul at Tien-Tsin, gives an interesting account of the construction of the first railway in China, the engineer of which is a member of the American Society of Civil Engineers. We abstract the report as follows:

Seventeen years ago the only semblance of a railway in the whole Chinese Empire was an iron tramway, about 10 miles long, at the Kaiping coal mines, 80 miles from Tien-Tsin. Small cars loaded with coal were pushed over this tramway by coolies, who received 10 cents in Mexican silver for 12 to 14 hours' work per day. About this time the works were placed under the charge of Mr. Claude W. Kinder, M. Inst. C. E. and M. Am. Soc. C. E., an energetic young English engineer, who at once ventured to propose many changes tending to increase the efficiency of the plant and to decrease expenses. The Chinese directors of the mines did not regard his efforts with favor and the Peking Government promptly vetoed his attempts at progressive measures. But despite the Peking authorities and native superstitions, Mr. Kinder determined to have a locomotive, if he had to build it himself, and he did build it. Four small driving wheels were ordered from the United States; a disabled stationary engine furnished the boiler, and a broken down winding engine the cylinders. With few tools and little outside help these parts were fitted together, and the "Rocket" was at last put upon the track with great yellow dragons emblazoned upon its sides. It was the first locomotive in China, and was a startling object to the Chinese, who expected all manner of dire consequences as the result of the innovation. The Peking authorities were horrified and at once ordered the Rocket dragon to be summarily suppressed. But the Chinese mine directors permitted it to be used in short trips inside the yard, at first, and its travels were gradually extended without producing the war, pestilence and famine expected. At last imperial permission was granted for its free use.

This was the beginning of railways in China, and the builder of the first locomotive is now Chief Engineer and Superintendent of the Imperial Railways of China. The line as at present finished begins at Tien-Tsin, it then passes 27 miles to Tongku, six miles from the mouth of the Pei-ho, at the Gulf of Pechihli. From Tongku the line swings northeast to Shang-Hai-Kuan, the terminus of the present operated road, and 177 miles from Tien-Tsin. Surveys have been made for an extension of 200 miles beyond Shang-Hai-Kuan, and about 10 miles have been built. When finished the railway is to reach Kirin, the centre of Manchuria, and a branch is to be built to the head of the Gulf of Liaotung, where there is a good harbor. Active work on this line was interrupted by the late Chinese-Japanese war.

The greater part of this railway runs through a flat, alluvial country, subjected to heavy floods dur-

ing the rainy season. The sharpest curve has a radius of 1,000 ft., and there is only one of these, made necessary to avoid two cemeteries. The most of the curves have not less than 3,000 ft. radius, and the maximum gradient is 0.75%. The country traversed is strictly agricultural, with no large towns, and the people are very poor. The Kaiping coal mines are the only mining industry in operation; though deposits of coal, iron, gold and silver only await intelligent development. All trains are "mixed" freight and passenger, with four trains each way daily from Tien-Tsin to Tongku, and one train daily from the latter point to the terminus. The average speed is 15 miles per hour, and while the road has paid its running expenses, it yields no interest on its first cost of construction and equipment.

The building was done after English methods and ideas of permanency, without regard to first cost or work required of it. No wooden structures find place upon it; stone, brick, concrete and steel being the materials used. The road is standard gage, with from 12 to 15 ins. of stone ballast, and is laid with steel 60-lb. Sandberg rails. These rails were rolled at Barrow, England, and were delivered at Takee for less than $21 per ton. The wooden ties are 8 ft. long by 6 ins. wide by 9 ins. thick, and are spaced 28 ins. between centres. These ties came from Japan, Oregon and Vladivostock, and cost about 72 cts. each in Mexican silver. Owing to the enormous rainfall of 140 ins. in a rainy season of four months only, the culverts on the line have unusually large openings. The soil is an alluvial deposit from 20 to 60 ft. deep. The masonry on the line is first-class cut-stone laid in English Portland cement, which latter costs about 75 cts. less per barrel than it does in the United States. All foundations are carried to the solid rock, caissons, sunk by the pneumatic process, being used for the deeper ones. The length of bridge spans varies from 20 to 200 ft., though the majority of the bridges are short and made up of plate girders.

The Lau-ho bridge is the most important engineering work. This bridge has two roadway spans of 30 ft. each, ten spans of 100 ft. each, and five spans of 200 ft. each; the total length between the faces of abutments being 2,170 ft. The 200 ft. spans are pin-connected and were designed by Sir Benjamin Baker on American types—with English details. Mr. Read criticises the result as curious and incongruous, especially in its peculiar lateral system.

The company builds all its own girder work up to 100 ft. spans. The main shops are at Tang-Shau, where cars and locomotives are repaired and all passenger and freight cars are built. All cars have four-wheel trucks, with iron truck frames, made by the company; the framing of the cars is teak wood, and the sides and tops are made of Oregon pine. With the exception of one American engine, built by the Grant Locomotive Works, the locomotives are all English or Scotch, of the mogul type. American cast-iron car-wheels have been tried, but the steel-tired European wheels are preferred. All cars are equipped with Janney couplers, the one American detail in the rolling stock.

The wages paid are as follows, all payments being at the rate of Mexican silver: Common laborers, $4 per month; firemen, $5 to $6; enginemen, $14 to $45. The two highest paid native enginemen now on the road receive $41 and $46 per month, while an English engineman receives $200 per month, as a maximum. The section-hand receives $4 per month; foreman, $6; a native clerk, $80, if he can speak and write both Chinese and English. The cost of timber is very great, and wooden trestles are out of the question. All station houses are built of brick, plastered inside, for the same reason, and station platforms are made of stone or concrete filled in with earth and cinders

THE PITTSBURG MEETING OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

The Pittsburg meeting was one of the best attended and one of the most interesting meetings that has been held by the Mining Engineers in several years. A large delegation of members went from New York city in a special car on Monday evening, which was joined by another party on reaching Philadelphia. By Wednesday evening 133 members, not including guests, were registered as in attendance. The first session not being convened until Tuesday evening, Feb. 18, all day Tuesday was available to members to visit some of the Pittsburg establishments, from many of which special invitations were received. Wednesday and Friday were also devoted to excursions by rail. On Wednesday visits were made to the Homestead Steel Works, the Westinghouse Electric Works and the Edgar Thomson Steel Works. On Friday the places visited were the McKee Bros. Glass Works, at Jeannette; the Latrobe Steel Works at Latrobe, and the Pennsylvania Salt Co.'s Works at Natrona. An account of these excursions and of some of the various interesting things seen at the different places must be deferred till our next issue.

The Kelly Pneumatic Process.—At the first session of the Institute, on Tuesday evening, was delivered the address of the retiring President, Mr. Joseph D. Weeks, on "The Invention of the Bessemer Process." What is commonly known as the Bessemer process is a combination of two metallurgical processes, that of William Kelly and that of Robert Mushet, carried on by means of apparatus invented by Mr., now Sir Henry, Bessemer. Mr. Weeks's address was devoted to presenting the claims of Mr. Kelly to be the first inventor of the fundamental feature of the so-called Bessemer process, the decarburization of liquid cast iron by blowing air into it. As these claims were sustained by the U. S. Patent Office in 1857, when he was granted a patent after the decision in his favor of an interference between his claims and those of Sir Henry Bessemer, and again by the Patent Office in 1871, when he applied for and received an extension of his patent, there can now be no question as to their justice, but Mr. Weeks has done a service to the history of metallurgy in now placing on record in the transactions of the Institute a complete exposition of the evidence upon which the claims were based.

Bessemer's first English patent was dated Oct. 11, 1855, and in an account of his invention of decarburizing cast iron (Eng. News, Oct 18, 1890), he says that the suggestion that led up to it grew out of conversations with the Emperor Napoleon III. and others during the Crimean War. As this war began in 1854, the earliest possible date of the first conception of his invention of decarburizing by a blast of air must have been 1854. But it was conclusively proved by legal evidence submitted to the Patent Office that Mr. Kelly, a native of Pittsburg, not only conceived this process of decarburizing, but actually practiced it at his forge in Eddyville, Ky., in 1847, and at the Suwanee Furnace, near the same place, from 1851 to 1857. Both Mr. Kelly and Mr. Bessemer failed in their early experiments to make good commercial steel, because cast iron simply decarbonized by air is red short, and it was not until Robert Mushet, in 1857, invented the addition to decarburized iron of the triple compound of iron, manganese and carbon, known as spiegeleisen, that the manufacture of good steel by the pneumatic process became possible. Kelly's apparatus was a stationary converter, and was small and crudely constructed. Bessemer's first apparatus was also a stationary converter, but he soon discarded this for the movable rotary converter, which is practically the vessel still used. Kelly was therefore the first inventor of the decarburizing process, Mushet contributed the addition of spiegeleisen to the red-short product, and Bessemer furnished the machinery which made the process commercially practicable. William Kelly was born in Pittsburg Aug 21, 1811. In company with his brother, John F., he went to Eddyville, Ky., in 1845, where they operated the Gemini blast furnace. They subsequently built the Suwanee furnace and operated the Union forge. The invention of the Kelly process was made for the purpose of rapidly decarbonizing pig iron for the use of the forge. In 1858 or 1859 Mr. Kelly returned to Pittsburg and also went to Johnstown, where he experimented with his process, but he went back to Kentucky in a short time, where he became connected with the Kelly Axe Co. of Louisville, Ky. He died Aug. 11, 1888. In a discussion which followed Mr. Weeks's address, Dr. Raymond, the secretary of the Institute, said that Mr. Kelly at first got from the Pneumatic Process Co., formed to operate under his patents in the United States, about $2,000 or $3,000, and upon the extension of his patents, about $25,000 additional, which is all the compensation he received, so far as is publicly known. President Weeks exhibited at this session a piece of nearly pure manganese, free from carbon, made by the process patented by Drs. Wahl and Greene, of Philadelphia. The oxide of manganese is treated with sulphuric acid in carbon crucibles lined with magnesite, no contact being made with the graphite. Pure aluminum is added, which unites with the oxygen of the oxide of manganese. The manganese is exceedingly hard and brittle, like steel in color, with a conchoidal fracture, and is almost entirely non-corrosive, differing remarkably in the latter respect from ferro-manganese.

On Wednesday evening the session was devoted to the reading and discussion of the following papers:

"Notes on the Walrand-Legenisel Steel-Casting Process," by H. L. Hollis, Chicago, Ill.

"The Embreville Estate of Tennessee," by Guy R. Johnson, Embreville, Tenn.

"The Magnetic Separation of Non-Magnetic Material," by H. A. J. Wilkens, South Bethlehem, Pa.

"Experiments in Sorting before Sizing," by R. H. Richards, Boston, Mass.

We will give an abstract of Mr. Hollis's paper in next week's issue. The paper on the Embreville Estate described the iron resources of a portion of East Tennessee. The paper by Prof. Richards described a method of separation of minerals, such as ores from gangue rock, which consists of two operations, first, the separation by "sorting," as it is called, in which the crushed material is allowed to fall by gravity through a pipe containing an ascending current of water. This separates heavy from light pieces, independent of their size, thus a small piece of galena and a large piece of quartz, both weighing the same amount will be carried by the current of a certain velocity. After thus sorting by weights, the quartz may be separated from the galena by "sizing" by ordinary screens. The magnetic separation of non-magnetic material is the paradoxical title of a paper describing a process of separation which has been invented by Mr. John Price Wetherill of Bethlehem, Pa., and is now in successful operation. What are called magnetic materials are those which are not magnetic by ordinary tests, such as most ores and rocks, but which, when tested by refined methods, show a very feeble magnetic permeability, say as little as 1-1000th part of that of iron. The process of Mr. Wetherill separates these materials from those which are absolutely non-magnetic or from those which have a negative permeability and repel the north pole of a magnetic needle The details of the process are for the present kept secret until the patents are granted, but it is expected they will shortly be made public. On Thursday, sessions were held both in the morning and in the afternoon. Papers were read by Thomas Robins, Jr., on "Conveying Belts and their Uses," and by Auguste J. Rosie on "The Effect of Titaniferous Ores added to Phosphoric Ores in the Blast Furnace" We will give abstracts of these papers in another issue. The principal business of these two sessions was the presentation of contributions on the subject of "The Physics of Cast Iron," a continuation of a discussion of the same subject at the meeting a year ago The most important paper on the general subject was presented by Mr. Alex. E. Outerbridge, Jr., on "Molecular Annealing of Cast Iron," and is reprinted in full elsewhere in this issue. Prof. R. C. Carpenter, of Cornell University, presented a brief note on the elastic limit and the modulus of elasticity of cast iron. It has been generally understood heretofore that cast iron had no well defined elastic limit, the strain diagram being a curve from its origin, and that the modulus of elasticity was a varying quantity, decreasing from the beginning of the test, but Prof. Carpenter shows that if after being strained in a test the load is removed, the iron then takes a permanent set, and if further tested it shows a well defined elastic limit at the point to which it has been strained, and a uniform modulus of elasticity up to that point. In connection with the general subject of cast iron, Mr. Thomas D. West read a contribution describing experiments on the expansion of iron at the moment of solidification. He showed that iron of different chemical constitution expand different amounts. Mr. West also presented a paper on "Standard Physical Tests for the Blast Furnace," in which he repeated his well known arguments in favor of a round bar for a test piece.

Changing the Grade of Pig Iron by Brushing.—Quite a little sensation was produced at this session by an exhibit made by Mr. Wm. R. Webster of the two fractured surfaces of a casting. Originally the fractures looked like very dark graphitic No. 2 iron, but by covering one half of the fractured surface with a piece of paper, and brushing the exposed portion vigorously with an ordinary nail-brush for a few seconds, all the flakes of graphite were brushed off, the color became very light gray, and on removing the paper the contrast between the dark and the light portion was as great as that between the "chill" and the soft part of the fracture of a cast iron car wheel. Pig iron "sharps," who pride themselves on their ability to grade iron by its fracture, were thoroughly puzzled by the sudden apparent change in the grade of the iron by brushing it. Whether a gray forge iron could be converted into a No. 2 by dusting its fractured surface with graphite flakes was not learned.

The following papers were presented in printed form, but were not read nor discussed:

"The Accumulation of Amalgam on Copper Plates," by R. T. Baylis, of Marysville, Mont.

"The Ore-Deposits of the Australian Broken Hill Consols Mine, Broken Hill, New South Wales," by George Smith, Broken Hill, New South Wales.

"Note on Carbon Bricks in the Blast Furnace," by R. W. Raymond, New York city.

"Notes on the Handling of Slags and Mattes at Smelting Works in the Western United States," by William Braden, Helena, Mont.

"The Cycle of the Plunger Jig," by R. H. Richards, Boston, Mass.

"The Effect of Vibration upon the Structure of Wrought Iron" (continued discussion).

"The Hydraulic Elevator at the Chestatee Mines, Georgia," by W. R. Crandall, Dahlonega, Ga.

On Thursday evening a banquet was given at the Monongahela House, at which about 140 members and guests were present.

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The notion that a constant jarring or vibration tends to make metals brittle is one which is thoroughly imbedded in the minds of the majority of so-called "practical" men, notwithstanding the evidence which has been presented at various times that no such supposed effect occurs. To the people who still adhere to this time-honored superstition—we can call it little else—we especially commend the paper on another page of this issue in which the claim is set forth that cast-iron is actually made tough by jarring or shock, instead of being crystallized and weakened. The interest of this new discovery from a scientific point of view is evident, and it promises also to prove of no small practical importance. If cast-iron can be annealed without the use of heat by simply subjecting it to light jars, it is entirely possible that many castings and forgings of iron, steel, other metals and even of some classes of earthenware might be annealed in this manner to advantage.

The first step towards state action to prevent the pollution of the Passaic River was taken on Feb. 25, when the New Jersey legislature passed an act providing for a commission to consider and report on the subject. The provisions of the bill are given in our news columns. An investigation of this sort has long been needed and the commission will have a grand opportunity to do work which will be of incalculable benefit to the communities directly affected, as well as to the whole state. The Passaic River is not alone among New Jersey streams in needing relief from sewage pollution, but its needs are by far the most urgent. Work there, if rightly done, may serve as a general model for later investigations of other streams, and also greatly lighten the work involved in making future studies.

Heretofore New Jersey has been one of the most backward states in the Union in the matter of preserving the purity of its streams. This has been due partly to the general indifference of the public, partly to the opposition of cities and manufacturers dumping sewage and wastes into streams, and partly to the efforts of the famous water syndicate, which sees a better market for its highland waters with the increasing pollution of the lowland streams.

The Passaic River ran very low last year, exposing the polluted condition of the banks and bed of the stream, and, through concentration, of the water of the river. The sights and smells were so disgusting that the people in the valley demanded relief in terms that brooked no denial. Whether the bill passed will give relief depends entirely upon Governor Griggs. He appoints the commission and he controls its expenditures, as none can be made without his approval.

Some comments seem to be again necessary upon the three separate bills now before Congress providing for a reorganization of the personnel of the Navy. We lately spoke of the parts of these bills relating to the steam engineering staff, and need say nothing more on that head; but the provisions of each bill are precisely the same in connection with the civil engineering staff, and there is a common and remarkable inconsistency in the treatment of this branch of the naval service. Under the proposed reorganization of the general staff corps, it is especially provided that the Chief of the Bureau of Medicine and Surgery "shall be appointed from the list of medical directors and fleet surgeons of the Navy;" the Chief of the Bureau of Supplies and Accounts "shall be appointed from the list of pay-directors and fleet paymasters of the Navy;" the Chief of the Bureau of Steam Engineering "shall be appointed from the engineer directors and fleet engineers of the Navy and shall be a skilled engineer." and the Chief of the Bureau of Construction and Repair "shall be appointed from the list of directors or inspectors of the Construction Corps and shall be a skillful naval constructor." But the Chief of the Bureau of Yards and Docks, eminently a civil engineering bureau and one in which all work is done by civil engineers, "shall be appointed from the list of line officers of the Navy not below the grade of commander."

Throughout these bills the phrase is often used: "Having regard only for the efficiency of the naval service and the special fitness of officers for sea and other duty." While the framers of the bills carefully and especially provide for this "fitness" in technical knowledge and experience in the case of the heads of all the other staff bureaus, this wise provision is entirely omitted in the appointment of the Chief of the Bureau of Yards and Docks.

But it is entirely clear that what is needed at the head of this bureau is a skilled civil engineer, while the line officer named belongs to a distinct and unrelated profession, and is quite as much fitted to head the bureau of steam engineering, or that of construction and repair, as the one provided for him in this proposed law. In fact, the discrimination made is unwise, unjust and invidious; and it is directly opposed to the "efficiency of the service" in excepting this one technical chief from the otherwise common requirement of special training and fitness for the duties of his office. The absurdity of having a line officer head a staff corps made up entirely of civil engineers has more than once been pointed out by this journal; and it has certainly seemed that any attempt to reform the many anachronisms and absurdities in the present naval system would include this important evil among those to be remedied. The civil engineering staff of the Navy is small in numbers, and its influence in the proposed legislation is evidently light. But the duties and responsibilities of individual members of this corps fully equal those of the other staff officers; and in the building and maintenance of our navy yards and in their equipment the importance of this work is second to none. Theirs is essentially a technical staff, demanding in its officers long and special training, skill and experience; and if the necessity for this skill is recognized in the case of the heads of two of the engineering bureaus, it certainly should be in the third. We would therefore suggest that the section of the bills referring to this branch of the service be amended, and made to conform with the provisions and requirements for the other corps of the general staff. This amendment should fix the title and relative rank of civil engineers in the Navy, a provision entirely omitted in the bills now before Congress; and it should then be provided that the Chief of the Bureau of Yards and Docks be "a skilled and experienced civil engineer," and that he shall be selected from the two lower grades of the officers of the corps. Such an amendment would be for the best interests of the service, in placing the affairs of the bureau in the hands of an expert, and it would place all members of the general staff on an equitable footing, without discrimination.

The need of more engineer officers in our Navy is well pointed out in a letter to the New York "Tribune," written by W. F. Durand, Professor of Marine Engineering at Cornell University, and himself one time an engineer officer of the U. S. Navy. Prof. Durand says that in 1882, when our "new navy" was started, there were in commission about 35 warships, aggregating about 25,000 I.HP. At the present time there are about 30 ships in commission, aggregating about 200,000 I.HP., or nearly eight times the steam power of the ships of 1882. Under existing law and by casualty the number of engineer officers has actually been reduced to 173, or about 100 less than there were on duty in 1880. The present staff is entirely inadequate to perform the duties imposed upon it by the changed conditions; and with $50,000,000 invested in warships it is plainly the duty of Congress to enact laws creating a personnel sufficient in numbers and training to properly care for the machinery of these ships and to maintain this machinery in a state of constant efficiency. The bills now before Congress fix the number of engineer officers at 303, or only 33 more than were on the rolls in 1880, when they had only one-eighth as much horse-power to care for. This certainly is not an extravagant increase.

"Data is being collected." "There is farther certain data." These specimens of "English as she is wrote" come from cultured Boston, in a circular issued by Mr. Edward Atkinson's Steam User's Association, and signed by a professor in an engineering school in that city. We believe that students in that school are required to pass an examination in English literature. Our reason for calling attention to the matter, however, is that this same error is constantly recurring in technical journals, proceedings of technical societies and in reports and specifications. In fact, it is so common that only vigilant editors and proof-readers succeed in keeping entirely clear of it. Yet it is always incorrect, for it violates one of the principal rules of grammar, viz., that a plural noun requires a plural verb. "Datum," meaning a fact given, is a noun in the singular number and "data" is its plural.

THE ERECTION OF MONUMENTS BY THE UNITED STATES GEOLOGICAL SURVEY.

In our issue of Dec. 12, we briefly discussed the need of properly monumenting the topographic work of the U. S. Geological Survey in order to make the work of the survey available for general public use, and it then seemed quite likely that the surprising neglect of the survey to perform this work in the past would soon be remedied by direct action by the Director of the survey. Since that date, however, the movement to effect this reform has received an unexpected check, and it now seems likely that no change will be made in the past methods of the survey unless Congress itself interferes, as now seems by no means improbable, and compels this reform.

The U. S. Land Office has been often and justly censured for its neglect in marking the corners which it establishes with nothing more permanent than wooden posts. But what sort of rebuke ought to be administered to the U. S. Geological Survey for carrying on its work year after year and erecting no monuments whatever by which its surveys can be made of public use.

For a number of years past this bureau has been engaged in a combined geological and topographical survey, spending from $150,000 to $350,000 per year. Admirable maps are published covered with 50-ft. contour lines and professing to give elevations above sea-level, in many places expressed to the single foot. But it was not until

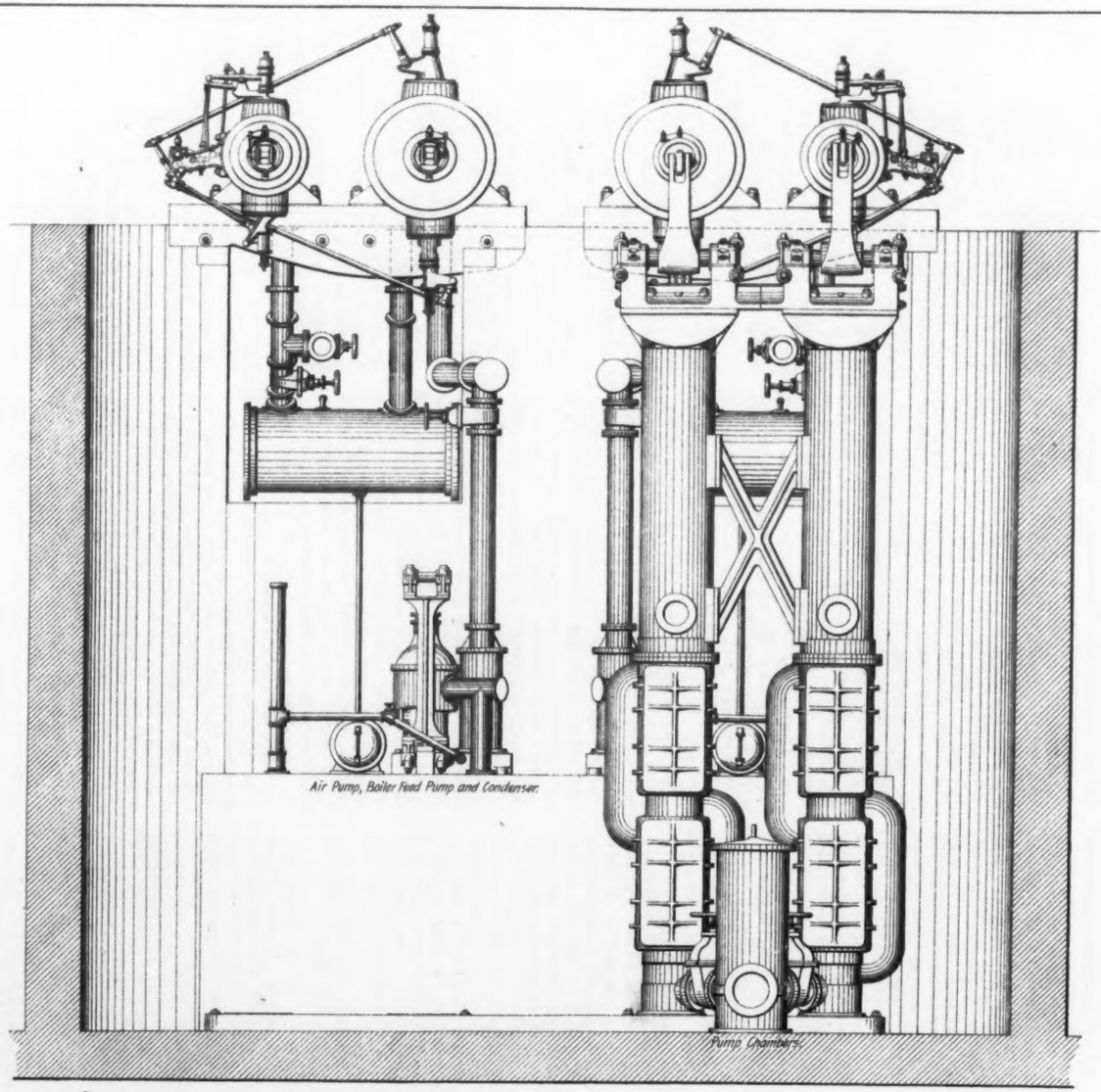
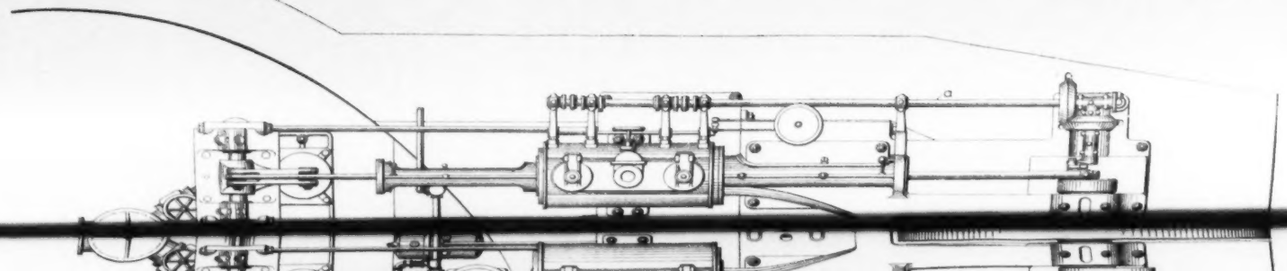
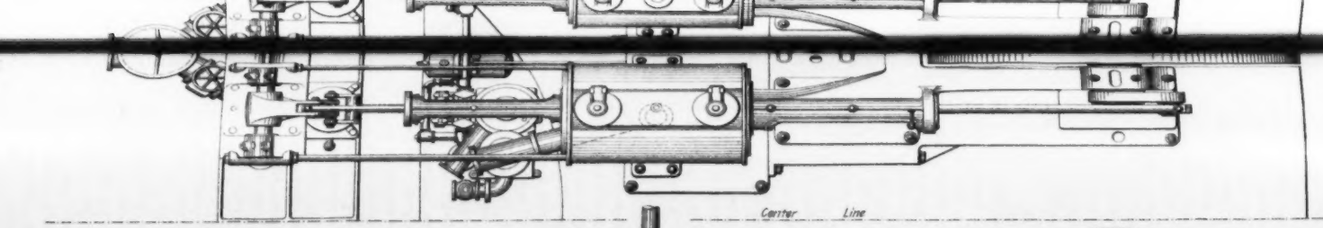


FIG. 2.

END ELEVATIONS OF PUMPS, CONDENSER AND AIR PUMP.



GENERAL PLAN.



GENERAL PLAN.

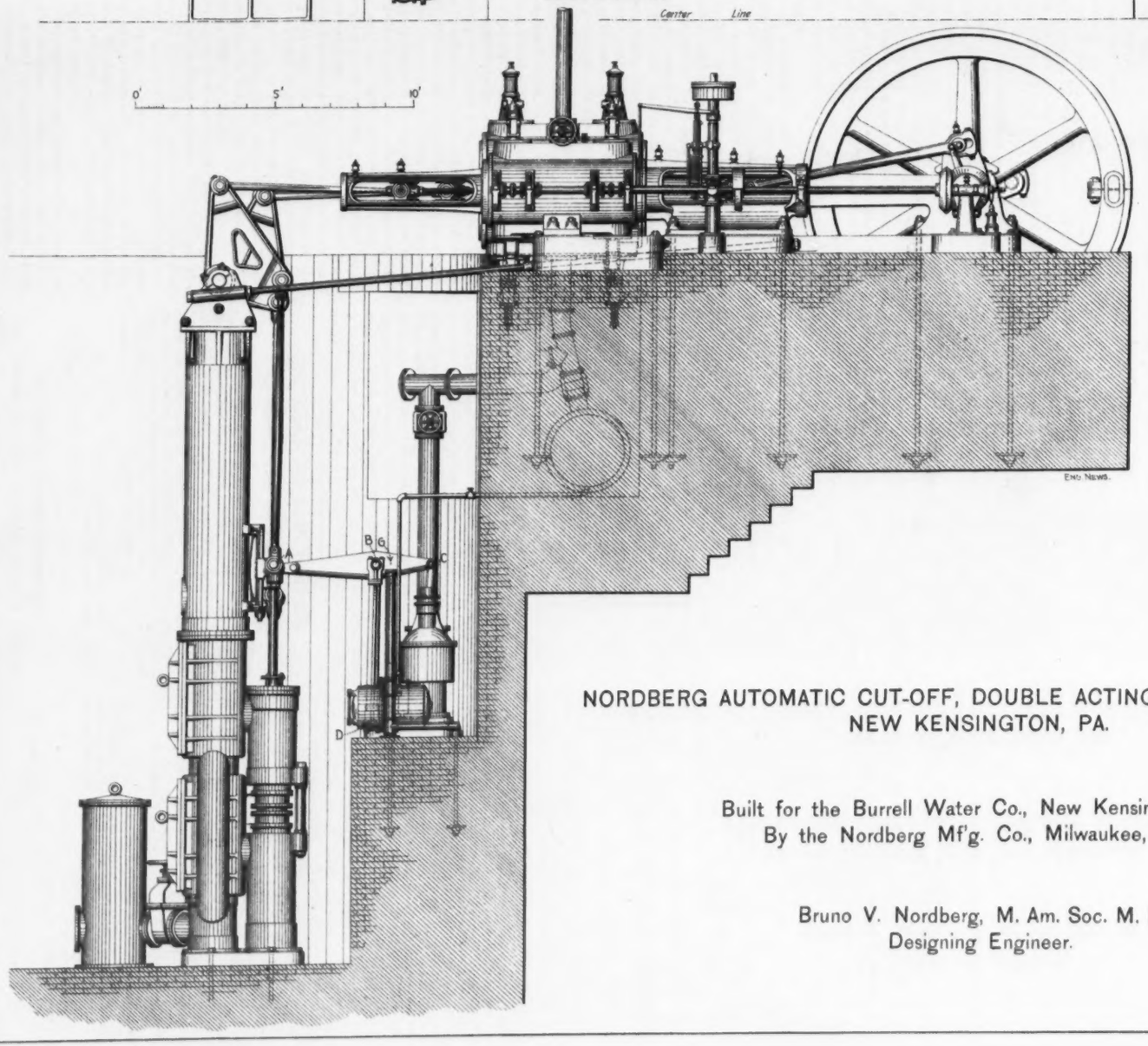


FIG. 1.

SIDE ELEVATION.

NORDBERG AUTOMATIC CUT-OFF, DOUBLE ACTING PUMPING ENGINE, NEW KENSINGTON, PA.

Built for the Burrell Water Co., New Kensington, Pa.,
By the Nordberg Mf'g. Co., Milwaukee, Wis.

Bruno V. Nordberg, M. Am. Soc. M. E.,
Designing Engineer.

CHAS. HART & BORD, LITH., 30 VESEY ST., N. Y.

the present Director took charge that any attempt was made to place upon these maps the ranges and township lines of the Land Office Surveys, or in any way to combine these two important though separate government surveys. The work of the Geological Survey and the maps it constantly issues would be of the utmost value in irrigation, drainage and other enterprises for internal development, were it possible to exactly locate upon the ground the topographical features thus mapped out. But 50 ft. contours and a scale of 2 ins. to the mile permit too wide a latitude for guessing, when it is attempted to locate points upon the map upon the ground, in the total absence of monuments and bench marks. Instead of being, as they should be, practically useful to the local surveyors and farmers, or the engineer of irrigation or other public works, these maps might almost as well not exist.

It is true that the original purpose of the topographic survey was merely the preparation of maps as a basis for the geological survey, and that extreme accuracy in the location of prominent landmarks and in obtaining elevations above the sea, was not necessary for this purpose, nor was it possible with the money and time expended. But a demand for the topographical maps themselves sprang up as a result of the geological work, and the government is now engaged in preparing and publishing maps of this description over a large area of the Far West. There is no doubt of the need for such maps in view of the rapid development of this part of the United States, and the maps published by the Geological Survey are most admirable in execution and detailed in their information. Rivers and lakes, railways and highways, towns and villages are all shown upon them. The general elevations are given by contours of 50 ft., and also by the elevations of various points, often expressed to a single foot, as 9,066 ft., for example.

The cost of permanent monuments would be trivial as compared with the cost of the surveys themselves; and these monuments need not be very numerous to meet all the demands of the case. One at township corners, for example, would require the establishment of a single elevation for each 18 square miles. If elevations to the single foot can be placed upon the maps, it would demand very little additional trouble and expense to permanently record this elevation upon the ground.

Why, then, have the monuments not been erected? Or leaving the past work out of the question, why should not the Director of the Survey immediately issue orders requiring their establishment on all work now in progress or to be hereafter undertaken? The reason which he gives, we are credibly informed, is that the funds at his disposal do not permit work of an accuracy that will warrant the establishment of monuments, and that he is not authorized by law to erect them. It appears to us that this is an explanation which does not explain. If the Survey can mark a point on a map as having an elevation of 9,066 ft., for example, it can erect a monument upon the ground and mark the same figures upon it; and the monument will serve many more practical uses than the map. The Survey should not only do this, but it should state on monument and map alike just what is the limit of error in the determination of the elevation, whatever that error may be. If the elevation of the monument or bench mark has been determined to one inch or one foot or ten feet or a hundred feet, let the fact be stated upon the monument. Then any one desiring to make use of the survey will know what he may rely upon.

What then is the real reason why the Survey has refused to erect these monuments, in reply to the urgent demand for them by engineers in the Far West? Can it be possible that it is feared that the erection of monuments would cause the work to be checked by other engineers and lead to the discovery of such discrepancies and gross inaccuracies as would forever discredit the work and lead to the abolition of the Bureau?

We hope that no such reason as this lies back of the present reluctance to undertake the work of monumenting; but if any such reason exists, past errors are no excuse for their perpetration in the future; and for the credit of the Survey and of the many able engineers in its service, it is to be earnestly hoped that the reforms above outlined will be inaugurated without delay.

Such surveys as the Geological Survey has undertaken are supposed to be made for all time; future work should simply elaborate and supplement the primary survey. In view of this fact great accuracy is advisable; and it can be secured, moreover, at no unreasonably great expenditure. Upon the lines laid down in the government surveys, many public and private interests hinge, and to correct blunders in these surveys at a later date may cost untold litigations and trouble.

The present Director of the Geological Survey, Mr. Charles D. Walcott, has shown energy and enterprise in advance of his predecessors in placing upon his maps the lines of the United States Land Office Surveys, and in other ways he has fostered reforms tending toward better work.

That he did not see his way clear to immediately inaugurate the establishment of monuments by the survey months ago, we believe to be a mistaken policy. We are glad to learn, however, that he has given his assent to an amendment to the appropriation for topographic surveys by his bureau, which has already been introduced by Congressman G. W. Mondell, of Wyoming, and which reads as follows:

For topographic surveys in various portions of the United States $ 00,000, to be immediately available, $100,000 of which shall be expended west of the 97th meridian, provided that hereafter in such surveys west of the 97th meridian the elevation above sea level, or some fixed point, shall be marked on the ground by iron or stone posts, or bench marks; at least two such posts or bench marks to be established in each township or equivalent area, and these shall be placed, whenever possible, on the township corners of the public land surveys, and the Director of the Geological Survey is authorized, wherever necessary, to retrace township lines and recover and mark township corners.

We are informed that this amendment is likely to receive the support of the Senators and Congressmen from the arid states, and there should be no question as to its successful passage. Our only criticism of the above amendment is that it does not go far enough. We know of no reason why the Geological Survey should be permitted to continue topographic work in any part of the country without suitably monumenting it. That the survey has been allowed to continue its work all these years and neglecting this important part of its duties without being called to account, argues, it must be confessed, that the public has found comparatively little use for its work, and it is by no means unlikely that this very omission of monuments is one main reason why greater use has not been made of it.

We might discuss in this connection, did space permit, the absurdity by which our national surveys are carried on by three separate and independent bureaus. But this is an old abuse, for which it seems hopeless at present to expect a remedy. The chronic evils of the Land Office survey work, also, are so well known and so hopelessly bad, that it seems useless to agitate for their remedy, especially as most of the work of that bureau has been completed and its errors are past remedy. The Geological Survey, however, is supposed to be conducted by able engineers and scientists, and to it we look for results of scientific accuracy. It is not too much to say, however, that if it continues to make surveys and to systematically omit to mark them upon the ground so that they will become matters of record and available for public use, it will have forfeited its right to exist.

LETTERS TO THE EDITOR.

The Masonry Water Tower at Lena, Ill.

Sir: Referring again to your issue of Jan. 16, and your comments on p. 40, it may be of interest to know that three weeks after the failure of this water tower (it having remained open weather all this time, or for the major part of it,) the subcontractor, in attempting to pull down the large portion shown in the extra high point in the cut, failed to do so after breaking a ⅞-in. steel cable, and it was necessary to pick the stone off with a steel bar, showing that the cement had hardened in the meantime to a very considerable degree.

Yours very truly,
U. S. Wind Engine & Pump Co.,
T. W. Snow, Asst. Gen. Agt.

Batavia, Ill., Feb. 13, 1896.

New York Civil Service Examinations.

Sir: I desire to inform you of the following examinations:

1. By the State Civil Service Commission, at this office, on March 5, at 10 a. m., examination for positions of deputy factory inspector, bakery inspector and mine inspector. The examination for each of above positions will be technical, and relate chiefly to the duties of the positions and the laws governing them. Candidates for deputy factory inspector will be required to show exact knowledge of locality in First and Second Inspection Districts. Applicants must be residents and citizens of the State of New York, and not less than 21 years of age. Applications must be on file in the office of the commission (Clarence B. Angle, Secy., Albany, N. Y.,) at least five days before date of examination.

2. By this Board, at this office, 10 a. m., as follows: March 3, chainmen; March 4, typewriter; March 5, inspector of electrical wires and appliances; March 10, inspector of buildings. It is required by law that candidates for this latter position have at least ten years' practical experience. Respectfully yours,

S. William Briscoe,
Secy. New York City Civil Service Boards.

New Criminal Court Building, New York City, Feb. 2, 1896.

Improper Use of the Term "Moment of Resistance."

Sir: I enclose a letter which I have just sent to the Carnegie Steel Co., in reference to what I conceive to be a misuse they make in their hand-book of the term "Moment of Resistance." I think this erroneous use of the term is leading to great confusion in the minds of practitioners and I fear if it is not corrected we may soon be in the throes of a new controversy as to the "true theory of the strength of a beam." If you think this is of sufficient public interest, you are at liberty to publish the enclosed letter, for the purpose of eliciting further discussion of the subject. Very truly yours,

J. B. Johnson.

St. Louis, Mo., Feb. 20, 1896.

(The letter enclosed by Prof. Johnson is as follows.—Ed.)

Carnegie Steel Co., Pittsburg, Pa.

Gentlemen: In the later editions of your hand-book you have used the function $R = \frac{I}{n}$ and called it the "Moment of Resistance." Here I is the moment of inertia of the cross-section and n is the distance from the neutral axis to the extreme fibre. The compiler of your hand-book, desiring to use this function separately, evidently adopted this name for it in the absence of any English usage on the subject, and because the Germans do use an equivalent expression for this function. In my opinion it is very unfortunate that he chose this term, since the "Moment of Resistance," as used in all the American text books and works on Mechanics, is in fact the above function multiplied by the stress on the extreme fiber in pounds per square inch. That is to say, the moment of resistance is in fact, and is always so stated in all the English engineering literature, so far as I know, $f\frac{I}{n}$ instead of $\frac{I}{n}$, as you have chosen to consider it, where f = the stress per square inch on the outer fibres, usually taken as 16,000 lbs. for steel beams. In fact $\frac{I}{n}$ is not a force or "resistance" moment at all. It only becomes such a moment when it is multiplied into a force. Furthermore the "moment of resistance" must of necessity be numerically equal and opposite to the bending moment, as these stand in the relation to each other of action and reaction, both being in inch-pound units.

As your hand-book has come into practically universal use in this country, I find that the new definition which you have given to the "Moment of Resistance" is leading to great confusion among those architects and engineers who have not received a good theoretical training in such matters. Furthermore this expression is liable to be incorporated into building laws with the significance which you have given to it, thus becoming absolutely misleading, since the term cannot be shown to have any such significance in any other work in English, so far as I know.

I admit that it is convenient to use this function, $\frac{I}{n}$, and to tabulate it by itself for the various structural forms which are rolled; but certainly you should give it a name which is not already universally applied to a different quantity. In order to make such proper use of it, you must, therefore, invent a name suitable to apply to it. I would suggest that you use the term "Moment of Resisting Area." This is in fact just what it is. It is the moment of the equivalent resisting area, if the entire area were concentrated at the distance of unity (one inch) from the neutral axis. This multiplied by the stress per square inch on the extreme fiber gives the "moment of resistance" of the beam in inch-pounds. Since, therefore, this function $\frac{I}{n}$ is in fact a reduced or an equivalent moment-area, and not a force-moment at all in any sense, you should, in my opinion, give to it a name which is not only appropriate, but which is, as far as possible, descriptive of its actual character.

Very truly yours,
J. B. Johnson,
Professor of Civil Engineering.

St. Louis, Mo., Feb. 20, 1896.

COST OF LIGHT RAILWAYS IN WESTERN AUSTRALIA.

Railway contracts in the colony of Western Australia have recently been let at very low prices, so low as to cause some of the English papers to

speculate upon the possibility of building even pioneer railways at such rates, although it has been pointed that on other cheap railways of this kind the contractors have completed the lines well within the contract limit and have pocketed all the receipts up to the specified date for completion. The particulars of the contracts for two new lines are as follows, both of 3 ft. 6 ins. gage.

	Southern Cross & Coolgardie Ry.	Northern & Yilgarn Ry.
Length, miles	114	170
Rails, weight per yd	45	45, 46¼
Cost per mile (contract items):		
Fencing, gates & cattle guards	$25	$170
Telephone, complete	.....	100
Telephone poles, erecting	20	.....
Grading	425	1,075
Culverts	85	140
Bridges	15	260
Ballasting and tracklaying, including sidetracks	425	1,040
Station buildings (freight and pass.), engine sheds, turntables, platforms, approaches and stationmasters' houses	405	445
Water supply	160	
Sectionmens' houses	70	
Ties	1,095	1,045
Maintenance, six months	305	80
Total contract price per mile.	$2,800	$4,355
Rails and fastenings (including $390 per mile railway freight to Southern Cross and $185 per mile to Northern)	2,330	2,505
Telephone material	300	.....
Rolling stock	1,575	1,200
Total cost per mile	$7,005	$8,060

THE WATER SUPPLY AND WATER CONSUMPTION OF PHILADELPHIA.

Through the courtesy of Mr. Jonn C. Trautwine, Jr., Chief of the Philadelphia Bureau of Water, we are enabled to make a graphic representation of the growth of the Philadelphia water-works from 1874 to 1895, and of the various estimates of future per capita consumption. Fig. 1 shows the number of the various water fixtures in use each year during the period. Fig. 2 combines in one diagram the growth in population, pumping capacity, total number of fixtures and buildings in the city from 1874 to 1895. Fig. 3 comprises various estimates of future water consumption, including a projection for the future along the line of increase for the past. The diagrams accompany Mr. Trautwine's report for 1895, an advance typewritten copy of which Mr. Trautwine also sent us.

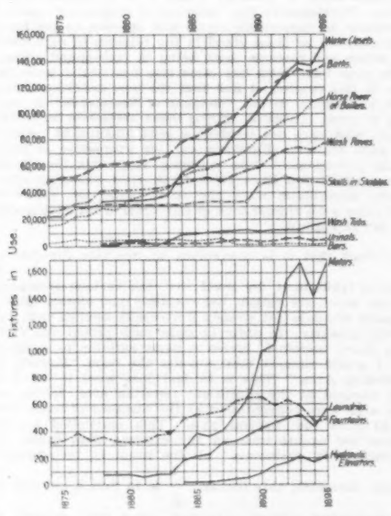


Fig. 1. Number of Fixtures in Use on the Philadelphia Water-Works, 1874-95.

One reason for the enormous use and waste of water in Philadelphia, which now amounts to 160 gallons per capita, may be that while 205,213 buildings are supplied with water, only 1,253 meters are in use. Regarding water waste and its prevention Mr. Trautwine makes the following pertinent remarks:

My predecessors have repeatedly called attention to the necessity for curtailing the reckless waste of water and have urged the use of water meters as the natural and proper means of effecting such curtailment.

In dispensing water otherwise than by meter, we are simply following a precedent established in the earliest days of water supply, and wholly unfitted to present conditions. To supply water at annual rates varying with the size of the attachment is as crude and unscientific as it would be for a merchant to charge his customer an annual rate depending upon the size of the doorway through which he took his goods.

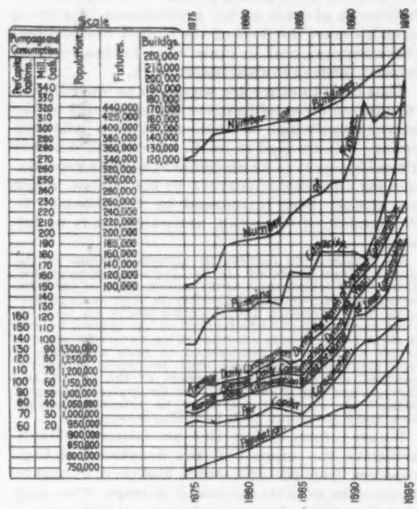


Fig. 2.—Population, Water Consumption, Pumping Capacity, Water Fixtures and Number of Buildings in Philadelphia, 1874-95.

The inadvisability of continuing the present method of charging for water may be understood when we consider what would be the effect of applying such a system (or no system) to the sale of gas.

To sell water by attachment rates is to place a premium upon the vices of prodigality and cupidity, for a person who wastes water or who uses an inordinate supply of it pays no more than one who practices every economy and whose requirements are moderate, provided the supplies be taken through openings of the same dimensions.

There is a widespread impression that the use of water meters tends to restrict unduly the use of water, particularly on the part of the poorer members of our population, who might, under a meter system, be tempted to restrict their consumption below that which is required to maintain the public health. It would, of course, be most unwise to adopt any measures which might lead to such restriction, but other cities have overcome this difficulty by fixing a minimum rate, below which nothing can be gained by economizing.

The department of public works is a socialistic or communistic organization, by means of which the entire community seeks to obtain certain results to the best advantage and at a reasonable expense. I take it, therefore, that the aim of the bureau should be, not to show a profit upon its transactions, but to furnish plenty of good water at the lowest possible cost to the community.

Acting upon this view, the introduction of meters should be governed, not by a desire to increase the city's revenue from water furnished, but, first, to decrease the city's expenditures by cutting off a waste which, under the present circumstances, appears little short of criminal, and thus enabling the bureau to furnish to all a plentiful supply with the means now at hand, and, second, to substitute a just, scientific, common-sense method of doing business in place of that which we have inherited from the earliest water-works practice, a method which would be ludicrous by reason of its clumsiness, were it not for the serious injustice which it involves. The meter rate is now, as it should be, approximately such as to supply the water to our manufacturers and other citizens at cost. If it is objected that the use of meters discourages our manufacturers, the rate may, if the city please, be still further reduced.

I have already referred to a case, developed in 1892, which showed, in a certain down-town district, a daily per capita consumption of 252 gallons; and you will notice that in Mr. Fuller's report mention is made of another, recently developed in the upper part of the city, where, by means of a house-to-house inspection of 142 small new houses on two intermediate streets in one block, it was found that, out of 782 appliances, 22 were leaking slightly and 32 running continually. The daily consumption per capita was found to be 222 gallons, and of this quantity 192 gallons were wasted and only 30 actually used.

It is for our citizens, through their representatives in councils, to decide whether it is best, for the privilege of thus throwing water, unused, into the sewers, to forego the benefits of a pure and plentiful supply. So long as this waste continues the city's financial resources will continue to be strained to their utmost to maintain it, and projects for genuine improvement must halt while the city grapples hopelessly with the task of filling a bottomless pit.

The present total annual increase in consumption is 18,000,000 gallons. The total reservoir capacity is 1,400,000,000 gallons nominal, but only about 1,000,000,000 gallons actual, owing to defective reservoirs. The latter is about five days' supply.

The year 1895 was the dryest experienced in the valleys of the Schuylkill, Lehigh, Delaware below Easton, and some smaller streams since the inauguration of the work of the hydrographic corps, in 1883, under the direction of Mr. John E. Codman. Some figures bearing on this point for the years 1894 and 1895 are as follows:

	1894.	1895.
Rainfall in Perkiomen Valley, ins.	50.40	28.68
Estimated flow of Schuylkill River, gallons	638,859,000,000	368,306,000,000
Total pumpage from Schuylkill River, gallons	67,158,000,000	73,106,000,000
Total pumpage from Delaware River, gallons	4,279,000,000	4,713,000,000
Total average daily pumpage, gallons	195,000,000	213,000,000

On the subject of the future supply for the city Mr. Trautwine recommends experiments on the filtration of the waters of the lower Schuylkill and Delaware rivers, close to the upper part of the city. Could this water be made potable by filtration the system could be extended gradually as needed, without the immediate outlay of such large sums as would be required for other possible plans. As to obtaining a pure mountain supply it would be difficult to find 200,000,000 gallons a day of unappropriated water without going far away and incurring enormous expense.

While the possibilities in this line should be investigated, Mr. Trautwine thinks that filtration should also be studied, as a possibly cheaper plan, even with pumping. The use of the Schuylkill is beset with some difficulties, for although it has an average daily flow of 1,000,000,000 gallons, the rights of the city in the stream are limited, and in addition other communities are appropriating or proposing to appropriate some of the yield of the drainage area. On account of these conflicting claims, which promise to be still more numerous in the future, Mr. Trautwine favors putting all the streams of Pennsylvania under state control. This is deemed necessary to prevent evident speculation in water rights, and notably to shut off pollution. Some of the water from the Schuylkill drainage area above Philadelphia already finds its way back to the stream as sewage, and more would do so if greater quantities were withdrawn for public use.

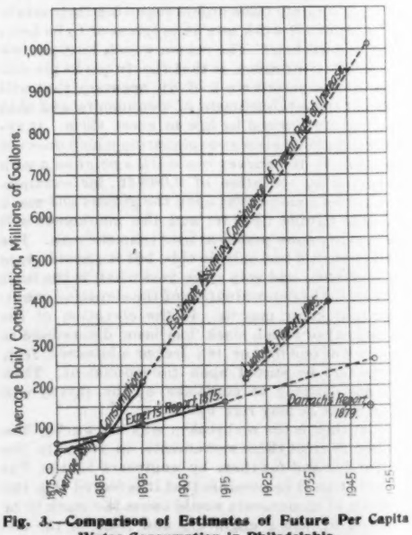

Average Daily Consumption, Millions of Gallons.
Estimate Assuming Continuance of Present Rate of Increase.
Actual Record.
Fuller's Report, 1875.
Darrach's Report, 1879.
Geographic Consumption.

Fig. 3.—Comparison of Estimates of Future Per Capita Water Consumption in Philadelphia.

On the subject of electrolysis Mr. Trautwine makes the following interesting statements:

Notwithstanding that there are now in operation in the city over 400 miles of electric railway operated by the trolley system, we have yet to learn of any well authenticated case of injury to our water pipes by reason of electrolysis. It is believed that this immunity is due largely to the effective bonding between the rails, upon which the electrical bureau insists.

RECENT DEVELOPMENTS IN AMERICA OF MECHANICALLY-PROPELLED ROAD CARRIAGES.

I.

General Review.

The idea of a mechanically-propelled carriage to run on the common roads is coeval with the higher development of the steam engine as a power generator by James Watt in the latter half of the eighteenth century. In Watt's patents for his improved steam engine in 1769 he mentions as one of the uses of his invention its application to road carriages. The English engineer seems, however, never to have made a practical application of his idea, but in the same year, 1769, the French engineer, Cugnot, built a steam road carriage which is still preserved in Paris. About the same time Hornblower, an Englishman, is stated to have invented a similar carriage, and a little later, in 1784, a Scotchman, James Murdoch, built and ran a steam road carriage with considerable success. In 1787 Oliver Evans, of Maryland, obtained a patent granting him exclusive right to make "a steam wagon for use on roads or railways." None of these early attempts to build steam carriages to run on the common roads materialized into anything of real service.

There were several reasons for this, but the principal one was that about 1802 Trevethick and Vivian demonstrated that it was possible to run locomotive steam engines upon a line of smooth rails, even upon slight gradients, and the attention of inventors was turned in a new direction. From time to time during all these early days of railways, but notably during the general railway craze of 1830, the attention of an occasional inventor was turned toward developing the steam road carriage, and naturally with much greater success than the earlier inventors mentioned, owing to the improvement of the locomotive steam engine and the increased knowledge of its workings which resulted from the great labors of Stephenson, Braithwaite, Ericsson and others. But on the whole the development of the railway absorbed the greater part of the inventive energy of these early engineers, and except for adoption for agricultural purposes, or for hauling heavy loads about docks, etc., the road engine attracted only occasional attention.

Well within the last decade the question of motor carriages for use on common roads, encouraged by the wonderful developments in motors, fuel and mechanical appliances generally, has again come to the front. France, with its excellent systems of government roads, was the first country to take the subject up in a public way, and all engineers are familiar with the great motor carriage races from Paris to Rouen in June, 1894 (Eng. News, Aug. 23, 1894), and from Paris to Bordeaux in June, 1895. Immediately following the French races of 1895 the Chicago "Times-Herald" offered premiums aggregating $5,000 for a motor carriage race to be held in Chicago on Nov. 2, 1895. This was the first contest of motor carriages ever held in the United States, and was disappointing to a very large degree; but the "Times-Herald," with commendable perseverance, renewed its efforts, and succeeded in developing a much more comprehensive and spirited contest on Nov. 28, 1895.

The conditions and results of the "Times-Herald" race will be described fully further on; but at this point the motor-carriage movement in other foreign countries than France may be briefly reviewed. In England, although that country claims to have produced the first successful motor carriage, inventors seem to have been slow to grapple with the problem in its later stage of development. One reason of this is ascribed to the English laws which prescribe that a motor carriage on a common highway must be preceded by a man carrying a red flag, and its speed must be limited to two miles per hour. This is, of course, a difficulty which proper legislation can overcome, and which will undoubtedly be overcome as soon as the popular sentiment demands it. That such a sentiment is being developed is shown by the fact that during October, 1895, an exhibition of motor carriages was held at Tunbridge Wells, England, which was well attended and extensively discussed in the English daily press. Beyond this one public exhibition in England, the movement for motor carriages in that country has been confined to a few persons who have used and manufactured such vehicles in a more or less experimental manner. In Germany the motor carriage has been developed to a quite high state of perfection by a number of manufacturing firms and notably by the firm of Benz & Co., of Mannheim; but so far as we know no public attempts similar to those in France and America have been made to bring it to the popular notice.

From the foregoing hasty review it will be evident that the motor carriage for use on common roads is by no means a new idea; that its practical development has passed the speculative stage, but is yet in its infancy, and that its possibilities as a safe and desirable substitute for the horse in many instances have only recently and to a limited extent been brought to the attention of the general public.

The Chicago Motor-Carriage Races.

A good idea of the attention which American inventors have devoted to motor carriages may be had by examining the files of patents granted during the last half century. Aside from their historical interest, these patents show little promise to the investigator until within the last decade; and it may be said, indeed, that the last year's work has developed more of practical working value than all that has gone before in the annals of American invention. To a very large extent the "Times-Herald" contest is responsible for this recent progress.

In the summer of 1895 the above-named journal announced that "with the desire to promote, encourage and stimulate the invention, development, perfection and general adoption of motor vehicles," it offered $5,000 in four premiums of $2,000, $1,500, $1,000 and $500, respectively, to be awarded in a contest to be held in Chicago Nov. 2, 1895. The conditions of this contest are abstracted from the official notice in the following paragraphs:

The contest is limited to motor-carriages or, as they are more commonly known, "horseless carriages." There will be eligible to competition any and all vehicles having three or more running wheels, and which derive all their motive power from within themselves. No vehicle shall be admitted to competition which depends in any way upon muscular exertion, except for purposes of guidance.

No vehicle shall be admitted to competition unless it shall comfortably carry not less than two persons for the entire distance, one of whom may have charge of the vehicle and the manipulation of the same.

No vehicle shall be admitted to competition except that it be free from danger, not only to its occupants but to spectators and the public users of the highways. The judges, at their discretion, may debar any vehicle which, from its construction, gives evidence of defects which would render the adoption of its type an evident impossibility.

For the purpose of limiting the contest to vehicles of practical utility a preliminary test of all vehicles entered for competition shall be held by the judges on Oct. 29, 30 and 31, under such rules as the judges may determine on, and for such a distance as they may decide. At this test the judges may debar such constructions as in their opinion do not possess features entitling them to further consideration. It is stipulated, however, that all motor vehicles which won prizes or honorable mention in the Paris-Rouen contest of 1894 or in the recent race between Paris and Bordeaux shall not be compelled to compete in the preliminary test, but shall be admitted upon proper application to the final competition on Nov. 2.

In making awards the judges will carefully consider the various points of excellence as displayed by the respective vehicle, and so far as possible select as prize winners those constructions which combine in the highest degree the following features and requisites, rating them of value in the order named: (1) General utility, ease of control and adaptability to the various forms of work which may be demanded of a vehicle motor. In other words, the construction which is in every way the most practical. (2) Speed. (3) Cost, which includes the original expense of the motor, and its connecting mechanism, and the probable annual item of repairs. (4) Economy of operation, in which shall be taken into consideration the average cost per mile of the power required at the various speeds which may be developed. (5) General appearance and excellence of design. While it is desired that competing vehicles present as neat and elegant an appearance as posible, it should be assumed that any skilled carriage maker can surround a practical motor with a beautiful and even luxurious frame.

A board of judges was appointed to determine upon the conditions of the race, to make the necessary tests for efficiency, etc., and to award the prizes. These conditions and tests were very comprehensive in character, but for reasons which will be mentioned further on, they will not be enlarged upon here.

The entries for the race were quite numerous, but as the date of the race approached one person after another withdrew, generally on the plea that they had not had time to complete their vehicles, until on the day of the race only two contestants appeared. One of these owing to an accident to his carriage, dropped out of the race, leaving but one motor carriage, entered by H. Mueller & Sons, of Decatur, Ill., to complete the course. The board of judges decided not to award any of the regular premiums on these conditions, but awarded a "consolation" premium of $500 to H. Mueller & Sons for their successful work. At the same time the "Times-Herald" announced that its original prizes and conditions would hold good for a contest to be held on Nov. 28, 1895.

The conditions established by the board of judges for the new contest were, broadly, that each contesting motor carriage should, first, be subjected to a laboratory test and, second, should cover a prescribed course of 54 miles inside of seven hours. The awards of premiums were to be made on the records shown both in the laboratory and service tests. A little further on the character and results of the laboratory tests, which were very complete, will be described; but the road test will be considered at once.

The rules for the road race were drawn with the view of giving each contestant a fair chance and related to right of way, receiving of outside help, etc. The course was over paved city streets and macadamized roads, some of which were in very poor condition naturally, but had been rendered much worse by a heavy fall of snow, which covered them with mud and slush from 6 ins. to 1 ft. in depth.

Mr. John C. Barrett, M. Inst. E. E., City Electrician of Chicago, one of the board of judges, in a semi-official announcement of the results of the tests, stated, "the roads were absolutely the worst I ever saw in Chicago." Owing to the bad condition of the roads, the time limit of seven hours was extended to include the time from 8:30 a. m. to 12 m. at night.

On the day of the race there appeared six contestants at the starting point, as follows: (1) Duryea Motor Wagon Co., Springfield, Mass.; (2) De La Vergne Refrigerating Machine Co., New York; (3) Morris & Salom, Philadelphia, Pa.; (4) H. Mueller & Sons, Decatur, Ill.; (5) R. H. Macy & Co., New York, N. Y., and (6) Sturges Electric Motocycle Co., Chicago, Ill. The action of each carriage during the race is given in the following paragraphs describing the construction of the respective vehicles. The premiums were awarded as follows:

(1) An award of $2,000 to the Duryea Motor Wagon Co., of Springfield, Mass., for best performance in the road race, for range of speed and pull, with compactness of design. (2) An award of $1,500 to the H. Mueller & Co. motocycle, of Decatur, Ill., for performance in the road race and economy in operation. (3) An award of $500 to the R. H. Macy & Co. motocycle, of New York, for showing made in the road race. (4) An award of $500 to the Sturges Electric motocycle, of Chicago, for showing made in the road race. (5) An award of the "Times-Herald" gold medal to the Morris & Salom electrobat, of Philadelphia, for best showing made in the official tests for safety, ease of control, absence of noise, vibration, heat or odor, cleanliness and general excellence of design and workmanship.

The following special awards were made by the committee on tests for meritorious points in design:

(1) An award of $200 to the G. W. Lewis motocycle, of Chicago, for friction driving device and brake and a reduction gear for increasing speed. (2) An award of $150 to the Haynes & Apperson gasoline motocycle, of Kokomo, Ind., for plan of preventing vibration by balance of driving engines. (3) An award of $100 to the Max Hertel gasoline motocycle, of Chicago, for a device for starting the motor from the operator's seat in the vehicle. (4) An award of $50 to the De La Vergne Refrigerating Machine Co., of New York, for counterbalance on engine.

Descriptions of Contesting Motor Carriages.

Duryea Motor Wagon Co.—Fig. 1 shows the motor carriage entered by this firm and which received the first award. It weighs 1,028 lbs. and is mounted on four wheels with pneumatic tires and ball bearings, the rear wheels, 45.6 ins. in diameter, being the driving wheels, and the front wheels, 27.4 ins. in diameter, being the steering wheels. The wheel gages are respectively 55 ins. and 53.7 ins., and the wheel base is 57.5 ins. The power is generated by a two-cylinder 4 × 4½-in. gasoline engine, designed by Mr. Charles Duryea, the inventor of the carriage. This vehicle has a carrying capacity for eight gallons of gasoline, and it also carries a tank of water to prevent the motor from overheating.

Fig. 1.—Duryea Gasoline Motor Carriage.
Duryea Motor-Wagon Co., Springfield, Mass., Builders.

The axletrees of the carriage are fixed to the body, dividing at the ends into vertical forks, into which are fitted pieces, like ordinary carriage hubs in shape, which hold the axle. Bolts run through these pieces, and a connecting rod of iron, extending back of the axletree and joined at the center of the wagon with the steering device, makes the separately-swung wheels work together. The lateral movement of the lever turns the wheels, and the vertical movement starts or stops, changes the rate of speed and reverses its movements, driving it backward when desired. Ball joints and ball bearings minimize all effort and friction, and minimize the power used. The brake drum is under the seat and is controlled by a wire with a button at the front corner of the seat, by which, under a speed of 12 miles an hour, the vehicle can be stopped in a few feet.

By the proper arrangement of gears, cones and levers, a change of speed is instantly effected by the vertical movement of the lever. In this machine the steering heads are placed as close as possible to the wheels, and at the same time are at such an angle that their line strikes the plane of the wheel at just the point a stone or other obstruction would naturally be encountered. This does away with the leverage which tends to turn the wheel, by breaking the force along the line of the head.

Fig. 2.—Mueller-Benz Gasoline Motor Carriage.
H. Mueller & Sons, Decatur, Ill., Builders.

Among the advantages claimed for this wagon are, little noise or odor, excellent springs, four speeds—five, ten and twenty miles an hour forward, and three miles an hour backward—can be quickly geared to different speeds; can be run at any speed desired below its limit; its fuel costs less than ½ ct. per mile, it runs from 100 to 200 miles without refilling; has self-oiling motors and bearings; will not jerk the levers out of the driver's hand, and is not dangerous either from fire or explosion. The retail price of this carriage is from $1,000 to $2,000, according to details.

In the race this wagon started at 8:15 a. m. and finished at 7:18 p. m. The steering gear was broken in running over a high railway crossing, causing a delay of 55 minutes, and later the sparker was broken, necessitating another delay of 55 minutes. There were also numerous slight delays owing to teams in the way, etc., but not due to the motor carriage. About 19 gallons of water and 3½ gallons of gasoline were used. The total time of the race was eleven hours and the distance 54 miles. The umpire who rode with the carriage stated in his formal report that he "estimated that enough power was used to run the wagon 120 miles over smooth roads."

H. Mueller & Sons.—Fig. 2 shows the motor carriage entered by this firm, which received the second premium. It weighs 1,636 lbs., and is mounted on four wheels with solid rubber tires and roller bearings, the rear wheels, 48 ins. in diameter, being the driving wheels, and the front wheels, 27.8 ins. in diameter, being the steering wheels. The wheel gages are, respectively, 50.2 ins. and 47.8 ins., and the wheel base is 73 ins. The power is generated by a one-cylinder 5½ x 6¼-in. Benz gasoline engine, and is conveyed to the driving wheels by a sprocket chain running from a belt-driven shaft.

Fig. 3.—Rogers-Benz Gasoline Motor Carriage.
R. H. Macy & Co., New York, Owners.

In the 54-mile road race this wagon started at 10:14 a. m. and finished at 5:53 p. m.

R. H. Macy & Co.—Fig. 3 shows this motor wagon, which was imported from France. It weighs 1,825 lbs. and is mounted on four wheels with solid rubber tires and roller bearings, the rear wheels, 47.6 ins. in diameter, being the driving wheels, and the front wheels, 35.8 ins. in diameter, being the steering wheels. The wheel gages are 52 ins. for both front and rear wheels and the wheel base is 67 ins. The power is generated by a single cylinder 5 × 7-in. Roger-Benz gasoline motor, and is conveyed to the rear drivers by a sprocket chain from a belt-driven engine shaft.

This machine started in the road race at 9:15 a. m., and followed the Duryea wagon closely until, in trying to turn to one side, a tire slipped and the carriage collided with a cab and bent the steering device so as to render it useless. The damage was repaired and the race continued until 6:15 p. m., when the motor failed and the contest was abandoned. At the time of stopping the Macy carriage was 25 minutes behind the Duryea wagon.

Sturges Electric Motocycle Co.—This motor carriage weighs 3,535 lbs., and is supported on four wheels with solid rubber tires and plain bearings, the rear wheels, 50.2 ins. in diameter, being the driving wheels and the front wheels, 46.4 ins. in diameter, being the steering wheels. The gage of the wheels is 57 ins., and the wheel base 65 ins. The power is generated by a 3-HP. Lundell motor, fed from a storage battery. The power is conveyed to the rear axle, on which the wheels are fixed, the carriage body being carried by the journals as a railway car is carried.

Fig. 4.—Lundell Electric Motor Carriage.
Morris & Salom, Philadelphia, Pa., Builders.

This vehicle started in the race at 9:01 a. m., and abandoned it at 1:25 p. m., the power being used up. During this 2 hours 46 minutes, stops of 33 minutes, 15 minutes, 14 minutes, 9 minutes, 10 minutes and a number of shorter duration were made to cool the field coils. In several instances the vehicle had to be pushed over bad places in the road. No breaks of any kind occurred.

Morris & Salom.—Fig. 4 shows this motor carriage, which is mounted on four wheels with pneumatic tires and ball bearings, the front wheels, 39.6 ins. in diameter, being the driving wheels and the rear wheels, 28.4 ins. in diameter, being the steering wheels. The wheel gages are 44.2 ins. and 36.1 ins., respectively, and the wheel base is 49 ins. The power is obtained from two 1½-HP. Lundell electric motors, the pinions of which gear directly to the driving wheels with a single reduction. The weight of the motor is 800 lbs., and the weight of the total carriage 1,650 lbs. The steering is accomplished by turning the hind wheels parallel with each other from a point about 3 ins. inside of the plane of the wheel, and connected by a rod to a vertical lever of a convenient height to be operated from the front seat of the carriage. Although at first sight it might be supposed that steering from the rear would be more difficult than steering from the front, yet, as a matter of fact, it is stated that this has been found not to be the case, as the carriage can be moved with the slightest effort on the part of the driver, and

Fig. 5.—Hornsby-Akroyd Gasoline Motor Carriage.
De La Vergne Refrigerating Machine Co., New York, Builders.

with the greatest certainty in any direction desired, and can be turned completely around in a circle of 20 ft. in diameter. The batteries consist of four sets of twelve cells each, having a normal capacity of 50 ampere-hours per cell. They are grouped in boxes, and so arranged that they can readily and quickly be pushed into place beside the body of the carriage, connection being automatically made with the controller. The controller is a small instrument which stands in a convenient position vertically in front of the seat, and is operated by means of a small hand-wheel on top. There are four speeds ahead and one backward, which are obtained by various groupings of the batteries and motors in series and parallel. The cost of the vehicle is $1,000.

In the road race this vehicle was started at 9:03 a. m., with the expressed intention of covering only enough of the course to demonstrate the commercial practicability of the machine. About 12 miles were run without stopping or accident, and with the machinery in good running condition at the end.

De La Vergne Refrigerating Machine Co.—A view of the motor carriage entered in the Chicago contest by this firm is shown by Fig. 5. This vehicle is mounted on four wheels with solid rubber tires and ball bearings, the rear wheels, 47.4 ins. in diameter, being the driving wheels, and the front wheels, 36.4 ins. in diameter, being the steering wheels. The wheel base is 66.7 ins. The power is generated by a single cylinder 5.12 × 6.62 ins., 5 HP. Hornsby-Akroyd gasoline engine, modified by Mr. Geo Richmond, M. Am. Soc. M. E., of the above company. The power is conveyed to the drivers by a sprocket chain from a pinion shaft actuated by a belt.

The peculiarity of this engine is that the gas explosion is neither by tube-ignition nor electric spark, but is entirely automatic. In order to start the engine a lamp is used for a few minutes to heat the vaporizer, the lamp being then extinguished and the required heat being kept up by the continuous explosions. A pump controlled by the governor supplies the proper quantity of oil. The speed of the carriage is controlled by a clutch. The motor can be stopped by turning a lever and the movement of the vehicle can be reversed without stopping the motor. The noise of the exhaust is stifled by a muffler in which is also placed a condenser that economizes the unburned gas.

In the road race this vehicle started at 8:56 a. m., but owing to the frequent stalling of the motor on account of the deep snow the contest was soon given up.

The conditions of the road race at Chicago, and the general character of the vehicles actually contesting, are pretty fully described in the foregoing paragraphs. In a following article a number of other motor carriages not competing in the race, but which have been developed to a high point of success, together with the results of the laboratory tests mentioned above, will be considered in such detail as their importance seems to warrant.

The U. S. Senate Committee on Fortifications recommends that a lump sum of $80,000,000 be set aside for building coast defences; $10,000,000 to be at once available, and the same sum used annually each year, for seven years. The report of the committee says that the aggregate value of destructible property in the 27 principal seaports of the country, and not including those of the great lakes, amounts to 10,000 millions of dollars. The Chief of Engineers says that the sum named would provide an efficient defense, but that no less sum would. The Senate committee also reports in favor of $2,500,000 for torpedoes. If this appropriation is granted provision could be made in 18 months for mounting 644 guns; of which 18 would be 12-in. and 103 10-in. guns, on disappearing and non-disappearing carriages.

Contracts for gun-forgings, intended for the batteries of the battle-ships "Kentucky" and "Kearsage," now building, have been awarded by the Navy Department. The Bethlehem Iron Co. has the 13-in. gun-forgings at 27.4 cts. per lb., and the 8-in. gun-forgings have been given to the Midvale Steel Co., at 28 cts. per lb.; both contracts are to be completed within one year.

An electric ice cutting machine is in successful use at Sunapee, N. H. It consists of a circular saw, which the operator is able to raise and lower at will. It has cut 65 ft. of ice to a depth of 9 ins. in 70 seconds.

THE OPERATION OF THE BROCKTON SEWAGE FILTER BEDS IN 1895.

As predicted during the construction of the intermittent filtration plant for the city of Brockton, Mass., the operation of these sewage disposal works is adding materially to the available knowledge of the subject of sewage purification, and supplementing by practical results obtained on a large scale the valuable deductions from the experiments conducted for so many years at the Lawrence Experiment Station of the Massachusetts State Board of Health. The credit for this is very largely due to the careful study and work of Mr. Herbert Snow, City Engineer of Brockton. Mr. Snow has kindly sent us the portion of his forthcoming report for the year ending Nov. 30, 1895, which relates to the operation of the beds. It contains so much practical and suggestive matter that we reprint it below practically in full. The disposal works, including receiving reservoir, pumping station, force main and filter beds, were described at length, with many illustrations, in our issue for May 2, 1895, to which reference may be made for the arrangement of the beds and details of construction. The extract from Mr. Snow's report is as follows:

During the past year such observations have been made and such information obtained, from the workings of the disposal system, as is possible without the assistance of a laboratory. By being unobjectionable to the senses of sight and smell, which have constituted our apparatus of investigation, the system has thus far justified its right to exist.

With us, the question of odors constitutes one of the most important factors in the problem of maintenance. The experimental tanks of small area have not been considered from this standpoint. Whatever odor arises from them is rapidly diffused, and thus diluted is not noticeable. But when odors, however faint, are given off from several acres, they cannot be so rapidly dissipated by the air. In short, the odor-creating ability of a large filtration field increases by some high power of the area, and it is probable that many experimental tanks, considered only from the standpoint of a pure effluent, have emitted odors which, if arising from a large area, would, if near a village, have caused complaints to have been made. Thus it may be seen that another factor, and this is the point it is desirable to make plain, may enter into the management and limit the capacity of a large filtration area to a greater extent than with the experimental tanks. In our case, it is necessary to dispose of the sewage without offensive odors, and it is possible that, in order to do this, smaller amounts and different methods of dosing, than those indicated by experiment on smaller areas, will have to be adopted.

Flow of Sewage.

It is estimated that at the present time about 3,000 people are served by the 221 sewer connections, which discharge into the system an estimated average daily flow of 60,000 gallons of sewage. It is probable that this flow is equal, in contained organic matter, to about 200,000 gallons of average town sewage. In the coming year chemical analysis will determine this question. The dilution of the sewage by leakage depends largely upon the height of the water in the Salisbury Plain River valley. A rise or fall of water in the river similarly and quickly affects the flow of the intercepting sewer. (The accompanying table shows the amount of sewage received at the beds during eleven months of 1895, and also the temperature of the sewage at the beds.—Ed.) It will be seen that the sewage is highly diluted.

Average Daily Discharge of Force Main at Brockton Sewage Filter Beds, January to October, 1895.

	Av. daily flow, gallons.	Temperature, degrees F.		Av. daily flow, gallons.	Temperature, degrees F.
Jan.	215,000	42.6	July	195,000	60.8
Feb.	169,000	40.6	Aug.	273,000	64.0
March	142,000	39.5	Sept.	275,000	64.0
April	250,000	42.3	Oct.	488,000	57.0
May	338,000	53.5	Nov.	474,000	51.0
June	228,000	60.1			

Size of Dose.

Speaking generally, it may be said that so far as the varying daily flow, due to leakage, would permit, each bed has received a dose of 75,000 to 100,000 gallons, applied every third day. In the latter part of the year, however, this dose has been applied every two days. Carriers were built in Beds 10, 12, 16 and 20, and on these sewage was first turned last year (1894). Carriers were put in Beds 8, 9, 12, and 17 about May 1, of this year; and in Beds 4, 13, 14 and 19 about June 1. In October they were built in Beds 5, 6, 7 and 18. It was found that a slope of 0.2 ft., per 100 ft., would effect the even distribution over the sand of 0.5 mm. (0.02 ins.) effective size, of a dose of 75,000 gallons applied in 20 minutes, and this accordingly has been the average size of the dose. In Bed 13, however, a fall of 0.5 was obtained and a dose of 45,000 gallons applied in 12 minutes, is evenly distributed. The slope given to the surface of the bed determines the evenness of distribution of the sewage, and hence the economic use of the filtering area. The necessary fall depends upon the size of sand grain, amount of organic matter in the surface sand, and also the size of dose and rate of application. It can only be reliably ascertained by actual experiment in each bed. In regarding a surface that has accumulated more or less organic matter, there is danger of reducing the effectiveness of the bed, by producing artificial stratification.

Present Disposal of Sludge.

The plan was to provide, during the early years of the system, for the removal of the heavier portions of the sewage at the receiving reservoir at the pumping station; but it has been deemed prudent to abandon this idea and to dispose of the solids, except what can be removed by screening, upon the filter beds. This practice, if continued, will seriously retard the process of filtration, so that as soon as the volume of sewage to be treated becomes considerable, settling tanks should be provided at the beds. Whatever sedimentation now occurs in the receiving reservoir is corrected by the agitator, and the sludge accordingly arrives at the field distributed through the liquid pumped, and forms a surface deposit upon the beds.

For a number of years the sewage will be from one to two days old when it reaches the field. In this time, important changes may take place in its composition. Such by-products of incomplete oxidation as carbonic acid, ammonia, carburetted and sulphuretted hydrogen are formed. By sedimentation, quite a percentage of insoluble matter and of the fats are deposited. These remain in heavy, gelatinous clots, which are easily precipitated and consequently hard to evenly distribute over the surface of the bed. The fats have, to a certain extent, been converted by the alkaline elements of the sewage the insoluble soaps or some more stable compound which clings to the sand grains and rapidly clogs the surface of the filter. It is, therefore, probable that the liquid pumped, though apparently diluted, may, by the changes resulting from decomposition, be compared with much stronger fresh sewage, in odor and ability to clog a filter. The formation upon the filtering material, in appearance, resembles axle-grease. It forms a covering which, to quite a degree, excludes air and acts like filter paper in removing and holding all the suspended matter of the sewage. Composed of paper, fats, and the less easily oxidized elements of the sewage, it creates little smell itself, even in warm weather, but it seems to strain out the more readily decomposable matter which soon manifests its odor-creating ability.

During the last two months, by a certain methodical use of the agitator, the time of the arrival of the sludge at the field is known and the dose has exclusively and alternately been applied to Beds 1, 2, 3 and 4. These beds have a surface of subsoil and their enrichment by the sewage will prepare them for cultivation next summer.

Raking.

The formation of surface deposit on the beds has made raking necessary. When a bed has received two applications of sludge it is usually apparent by the increased time of absorption that it should be raked. By raking, is meant the stirring up of the surface to a depth of 2 ins., or less, and the removal of the scum. The effect of leaving the deposit undisturbed was tried on Bed 16, which was not raked from Jan. 12 to Aug. 1, when the deposit in some places was ½ in. in thickness; the time of absorption had doubled, and an odor, apparent several hundred feet from the beds was emitted.

On removing the scum, the sand was found to be discolored to a depth of 3 ins. The bed was raked and given a rest of ten days, at the end of which time it had brightened considerably and the time of absorption had become normal. Raking has had less effect on the time of absorption in beds of coarse sand, where the organic matter goes deep, than it has on those of fine sand. During the summer, each bed was raked once in two weeks. The deposit removed has been reduced to ashes by a fire of cord-wood.

Effect of Frost on Level Beds.

Considerable ice began to form early in December, 1894, around the edges of the level beds, and gradually to approach the carriers. The temperature of the sewage, at this time about 44° F., was readily chilled by the snow to a point where it had little power to melt the ice. Observations made while putting sewage into snow showed the temperature to be: In the pipe, 45° F.; 20 ft. away from the carrier, 43°; 50 ft., 42°; 75 ft., 37°; and beyond this the sewage did not penetrate the snow at all. Within this area the liquid retained in the upper inches of the filter by the accumulated organic matter froze solid. At a greater depth than 2 ins., less liquid being retained by the sand grains, though frozen, the mass remained porous. If there had been warmth enough in the applied sewage to thaw the upper layers, it would readily have passed through the lower porous, though frozen sand. But it is easy to understand how the sewage flowing in a thin sheet became chilled by the ice and snow to the point where it could not thaw its way through

the upper frozen layer, thus rendering the level beds entirely useless until warmer weather.

Effect of Frost on Furrowed Beds.

Profiting by the first winter's experience with level and furrowed surfaces, all the beds have been furrowed this fall. Flowing in trenches, the sewage exposes less surface to the cold and its warmth is longer retained. It was noticed that while on level beds the frost was rarely thawed to a greater depth than 2 ins., the hollows of the furrows were usually clear of frost to a depth of 6 ins. after an application of sewage.

Subsidence does not take place until the heat of the sewage thaws the bottom of the furrows. During this period of no settlement a thin sheet of ice usually forms on top, the temperature of the sewage at this time being about 38° F. The frost being removed at the bottom, subsidence follows, and the thin sheet is left spanning the trenches to serve as a protecting cover. The remaining portion of the sewage settles into the filter without freezing. Naturally, an impervious layer of sludge forms in the bottom of the trenches, which tends to hold liquid, and gradually a thin layer of ice may attach itself to the sand. This is a serious result of overtaxing a furrowed bed. The objectionable feature of furrows, as we use them, is the increased difficulty in cleaning in the spring. The formation of deposit under the ice is more or less rapid, the decreased air circulation making its accumulation more noticeable. As long as the sludge deposit remains frozen no odor results, but as soon as spring comes the odors are manifest, though not constituting a nuisance by any means. The deposits were removed early in April, since which time no odor sufficient to be called objectionable by the most sensitive has been apparent.

Underdrains.

Regular observations have been made of the ground water and flow in the underdrain. A weir with automatic recording instrument has been placed on the 12-in. underdrain. It has been found that the water table has not yet been raised by the sewage. The 5-in. drains discharge effluent from all the beds, except Nos. 5 and 10. The 15-in. pipe which passes through these beds probably keeps the sand drained below the level of the upper pipes. Approximate measurements of the effluent indicate that less than one-fourth of the sewage applied flows from the upper 5-in. drains of any of the beds. In Bed 4, the time of its appearence varies from two to four hours after the time of applying sewage; in Bed 6, from 55 to 80 minutes; in Bed 7, 60 to 100; Bed 8, 20 to 50; Bed 9, 30 to 100; Bed 12, 35 to 100; and in Bed 13, from 40 to 60 minutes. In the latter bed no effluent ever flows from a smaller dose than 100,000 gallons.

Conclusion.

The cost for the year of running the pumping station and the filter beds has been about $6,000. The working of the system has been most satisfactory. No nuisance has been occasioned, and nothing unsightly has been permitted about the field. The embankments and beds have been kept in a condition which has rendered them objects of pleasurable interest to the large number of visitors who have made the place an objective point in their driving.

The removal of the surface deposit, the daily refilling of the force main, the grading of the beds and consequent even distribution of the sewage, the cleanliness of the carriers, and a system of dosing suitable to the varying sands of the different beds are the important features in the successful management of the filtration field.

NORDBERG COMPOUND PUMPING ENGINE; NEW KENSINGTON, PA.

(With Inset.)

We illustrate on our inset sheet and in the accompanying cuts this week a compound, double-acting pumping engine, with automatic cut-off, which possesses several features of more than usual interest. This engine is one of a plant of two engines constructed for the Burrell Water Co., of New Kensington, Pa., by the Nordberg Mfg. Co., of Milwaukee, Wis. The engine parts are horizontal while the pump parts are vertical. This construction was determined by the great difference of water level at different times in the Allegheny River, from which the water is taken. The pumps stand in a large water-tight pit built of brick, and during high water in the river the water level comes within 5 ft. of the engine room floor, while at low water the level is considerably below the bottom of the pit.

The drawings on the inset sheet show the general construction. Fig. 1 is a side elevation of the engine, pump, and air pump and condenser. The power from the horizontal engine cylinders is transmitted to the vertical pump rod by means of a bell crank, and the air pump and boiler feed pump are actuated by means of a walking-beam connected to the pump rod. Fig. 2 shows end elevations of the pumps and the air pump and boiler feed pump. By examining this drawing in connection with Fig. 1 it will be seen that either pump can be disconnected from the engine and repaired or overhauled while the remainder of the machinery is kept running, by simply closing the gate valves on the suction and discharge nozzles of that pump and taking out the connecting rod between the bell crank and plunger rod. Fig. 3 is a plan showing the location of the two pumping engines forming the pumping plant.

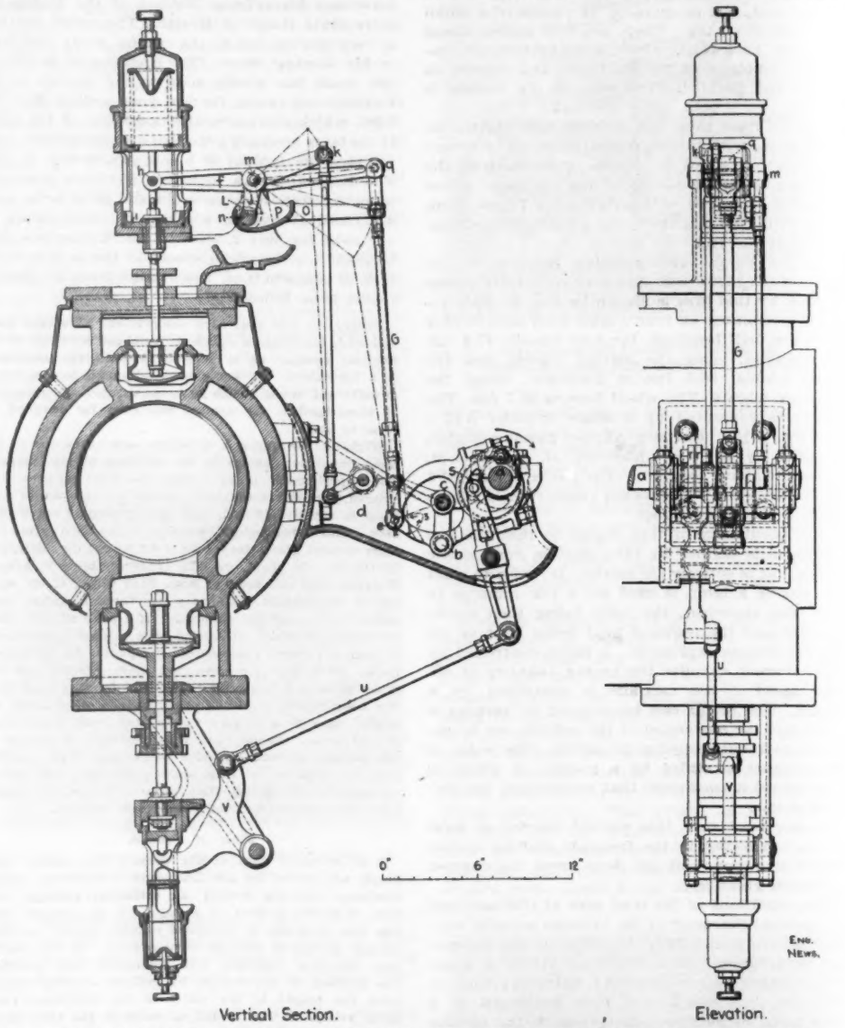


FIG. 4.—NORDBERG PATENT POPPET VALVE GEAR, FOR PUMPING ENGINE AT NEW KENSINGTON, PA.
Bruno V. Nordberg, M. Am. Soc. M. E., Designer.

The engine is a compound, with cylinders 40 ins. stroke and 19 and 36 ins. diameter. The piston rods extend through the cylinders, connecting at the front end with the flywheel crank shaft and at the back end with the bell cranks operating the plungers. The cylinders, including the heads, are steam-jacketed, the jacket being cast onto the cylinder, as shown by Fig. 4.

By far the most interesting part of the engine is the valve gear, which is of the Nordberg patent poppet valve type, and is shown in detail in Fig. 4. This valve gear controls four double-beat poppet valves on each cylinder, two for inlet and two for exhaust, and has a range for cut-off from 0 to 9-10 of the stroke. The compression on both cylinders and at each end can be independently adjusted, and in such a way as to define the point of release and the lift of the valve. On the high-pressure cylinder a compression of 3-10 of the stroke can be obtained, and on the low-pressure cylinder a compression of ½ of the stroke.

The valve gear is of the releasing type, and is constructed as follows: a is a lay shaft driven by cut miter gears from the main shaft of the engine. On this shaft are mounted the eccentrics and cams necessary for operating the four valves to each cylinder, there being one eccentric for each inlet valve and one cam for each exhaust valve. The shaft rotates in the direction of the arrow. One point, b, of the extended eccentric strap is guided so as to describe a circular arc when the eccentric rotates. This is done by suspending it on a radius rod on a pivot, c, which is fixed to a bracket, d, bolted on the cylinder. This causes the pin e on the eccentric strap to describe a curve, as shown by the dotted line, which pin is connected to the valve-operating lever by a rod, G. The lever f is pivoted by pin h to the dashpot plunger i, and at a point midway between pivot h and pin on which rod G is connected the trip lever j is pivoted. This trip lever is held by the governor by a rod connected to pin k, and is provided with a circular face of hardened steel, L, the circle being struck from the center, m. The face L bears on a corresponding face, n, on the rocking lever o, which is pivoted on a point fastened to the valve bonnet in direct line with point m. The rocking lever receives its motion from an arm, c c, cast in one with the radius rod b c, which has a motion that is slightly in advance of the motion of the piston of the engine. The rocking lever has cast on it an oil receptacle, p, in which the hardened faces L and n are submerged. When the eccentric is at the point shown by the drawing, the center of pin e is at the point 1 of the motion curve, and the faces L and n just came

into contact. As the rod G descends, the lifting lever f is rotated around point m and lifts the valve, point 2 on motion curve being the position of pin e when the crank is on dead center. The two arms of the lifting lever f should be nearly equal, consequently the valve opens with a speed nearly equal to that at which the rod G moves downward. The pin e travels in the direction shown by the arrow, and when it has arrived at point 3, the valve is gone down on its seat, the piston having traveled 9-10 of the stroke.

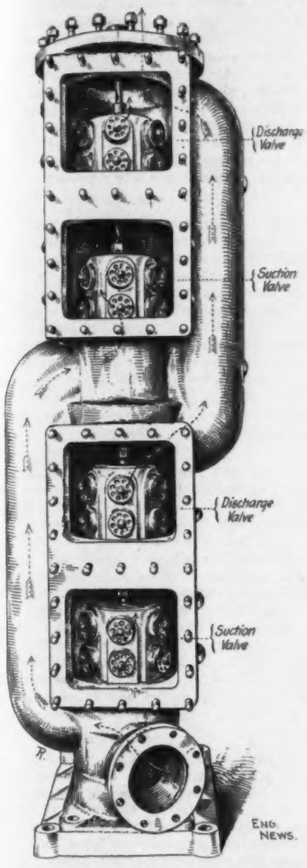


Fig. 5.—Sketch of Water Valve Chamber Casting, Showing Location and Operation of Valves.

After having passed point 3, the faces L and n move out of engagement, and the point h now becomes the turning point of this lever, which becomes one of the second order. During the period of motion of pin e from 3 to 1, the faces L and n are out of contact, and it is clear that the velocity at which they move in contact is very slow, or about one-half of the downward velocity of the rod G, which velocity, during the motion from point 3 to point 1, is very slow.

In the foregoing description we have assumed that the trip lever j was held by the regulator in such a position that no release took place. The release is effected whenever the trip lever j and the face L connected thereto are held by the governor in such a position that the motion of the rocking lever o brings the face n out of reach of face L, in which case the valve drops, q being the turning point of the lever f. By holding the trip lever j and pin k in different positions, the trip can be effected at any point of the stroke, or any position of the pin e from the point 1 to the point 3 on the motion curve.

The advantage claimed for this motion is that the engagement between the two parts constituting the trip mechanism, in this case, faces L and n, takes place at a very low speed, while at the same time the opening of the valve is rapid and the range of cut-off great. Another advantage claimed is that the engagement of the two parts constituting the trip is effected by a positive motion derived from the eccentric without the aid of springs, as in the case of Corliss engines, which enables the valve motion to be run at considerably greater speed than any other releasing mechanism. The inlet valves are made of hard phosphor-bronze, which has been found especially durable against wear and consequent leakage due to wet steam, mud from the boilers, lack of lubrication, etc. In case of damage to any individual valve, it can be easily ground to a bearing, or, if necessary, can be removed altogether with its seat and replaced by a spare valve in a few hours. As there is no sliding action to these valves, their proper working is not dependent upon the lubrication or the dryness of the steam.

To cushion the inlet valves a dashpot is provided. This dashpot is set with very little clearance on the bottom (about one thickness of ordinary drawing paper). The air from this dashpot is discharged freely into the atmosphere during the drop, until the valve comes within one-eighth of its seat, when the cushion commences.

The exhaust valves are operated by means of revolving cams, r, on the lay shaft. The cams are made in halves. The opening side of the cam is keyed on the lay shaft, while the closing side can be shifted around. The cam works in contact with the roller s on the lever T, from which the motion is conveyed to the exhaust valve by the rod u and rocker v. By this arrangement the point of release and total lift of the valve remain the same, no matter at what point of the stroke the compression commences. The arrangement of the low-pressure cylinder is slightly different.

All pivots about this valve motion are made of hardened tool steel, running in hardened bushings, the pins and bushings being ground to an exact fit. The valve stems are made of high carbon steel. The lifting levers, radius levers, exhaust levers f and other levers subject to strains are made of mitis iron. All the rods in this valve motion are subject to tensile strains only.

The trip mechanism operating the inlet valves is controlled by a governor, by which the point of cut-off is set to correspond to the load, the arrangement being such that a range of cut-off from 0 to 9-10 of the stroke is effected. It will be remembered that the range of cut-off in the Corliss engine, as usually constructed, is from 0 to 4-10 of the stroke, so that should the load increase to an amount where an admission of steam of 4-10 the volume of the cylinder is not sufficient, the engine will take steam at full stroke. While it is not profitable to run engines under such heavy loads as will require a steam admission of over 4-10 the cylinder volume, there are occasions when such loads occur. A notable instance of this is in rolling mill engines. The advantages claimed for the Nordberg valve gear are that such increases over the rated load are handled without either causing an excessive strain or the irregularities of motion due to admitting steam during the full stroke.

To make the governor respond quickly to any change of load, and to prevent effectively any possibility of the engine running away through failure of the governor-driving mechanism, the governor is run by gears from the valve motion shaft.

The foregoing description, with the aid of the illustrations, gives a clear idea of the construction and operation of the steam valve gear. In reference to its advantages, Mr. Bruno V. Nordberg, M. Am. Soc. M. E., the designer, writes us as follows:

> As with the double beat equilibrium poppet valve, we claim that this type of valve is particularly suited for high boiler pressure, which at Kensington is about 130 lbs. per sq. in. That this is the case is evident from the fact that these valves are nearly perfectly balanced, and that there is no friction between the contact surfaces, for which reason the factor of lubrication is eliminated as far as the valves go. Another advantage is that the clearance is reduced to quite a small fraction by the use of these valves on steam-jacketed engines. Such clearance is greater than it would be with Corliss valves placed in the cylinder heads, but rather less than if Corliss valves were placed in the ordinary manner, at the same time the surface of the valves exposed to the expanding steam is less.

The engine frame is of the girder type, and is made in one piece with the main bearing, which is mounted on a bedplate extending the full

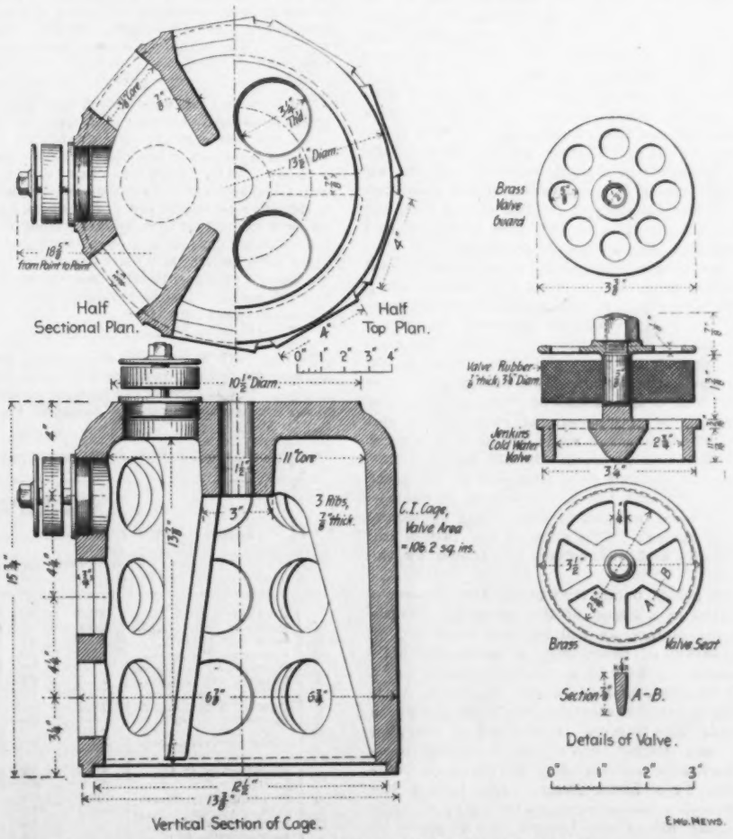


FIG. 6.—DETAILS OF WATER VALVES AND VALVE CAGES.

length of the engine and bolted to the masonry foundation. To prevent vibration of the pump chambers on account of the motion of the pistons, a pair of wrought iron rods connect the bedplate with the top of the pump chamber. It may be noted here that this device has proved efficient for the purpose, and that practically no vibration is caused in actual operation when the engine speed is 45 revolutions per minute, making a piston speed of 300 ft. per minute. The cylinders do not rest directly on the bedplate, but have a bearing plate interposed, which is planed to an accurate fit. The bolts holding the cylinders are so made as to allow them to expand freely, a feature which, so far as we know, is not adopted in any other engine. Its importance, however, will be realized when it is remembered that a cylinder 5 ft. long is over 1-10 in. longer when under 100 lbs. steam pressure than when cold. The piston rod is of steel 2 15-19 ins. in diameter; the crosshead pins are 3 7-16 × 5 5-8 ins., and the connecting rod is of a solid end type, so constructed that the brasses cannot pinch the pin in the case of heating. The crank pin is 4⅞ ins.; the crank shaft 10 ins., and the flywheel 12 ft. in diameter. It may be noted that all connecting-rod boxes are of the same design as that at the crosshead. The peculiarity of this box lies in the fact that the stationary box is cylindrical, with one side cut open, so that the adjustable box projects into the stationary box through this opening. The object of this construction is to prevent the boxes from partaking in the rotation or oscillation of the pins.

The stroke of the engines, which is 40 ins., is reduced to a stroke of 26 ins. for the pump plungers by means of the unequal arms of the bell cranks. From the short arms of the bell cranks the power is conveyed to the pump rods by means of connecting rods whose crossheads run on vertical guides attached to the pump chamber. The pump rods are of steel lined with bronze and 3½ ins. in diameter, and the plungers are 12⅛ × 26 ins. and outside packed. The pump cylinders are 12⅛ × 27 ins. As will be seen, the pumps are made in a single casting, with the air chamber forming a continuation of the discharge chamber and bearing on its top the bell cranks just mentioned. The suction pipe is 12 ins. and the discharge pipe 10 ins. in diameter.

Fig. 2 shows the locations of the suction and discharge nozzles and a front view of the pump castings, and Fig. 5 is a sketch showing the casting of one pump with the manhole covers removed and the valves exposed to view. The captions on this sketch show the course of the water, and indicate the suction and discharge valves clearly. Fig. 6 is a detail drawing showing the construction of the polygonal valve cages and valves. The valves are made of rubber and work on phosphor-bronze seats. It will be seen that the guard is screwed on a stud cast in one piece with the seat and has a check nut to hold it. The valves are brought to their seats by means of bronze springs. The area of the valves and other details and dimensions are shown by the drawings.

The air pump, boiler feed pump and condenser are located in a recess of the pump pit directly behind the pumps, as will be seen from Fig. 2. The operation of these devices needs but little explanation. There is a beam mounted on a rocking support, B D, one end of which, A, is moved in a vertical straight line from the pump crosshead. The fulcrum B and end C carrying an air pump bucket, have then a slightly horizontal swinging motion. The air pump is a single-acting 14 × 14-in. pump. The bucket has flexible suction valves mounted on top of it, while immediately above the bucket is a plate on which the discharge valves are mounted, the plunger rod passing through this plate through a stuffing box. The top of the plunger rod is keyed into a long cylindrical guiding piece or crosshead, in which the lower end of the connecting rod is held. This crosshead passes through a stuffing box. It is plain from this description that the stresses on the support B D are all compressive.

At the point G, the feed pump is pivoted. This pump is 4 × 6 ins., and it draws its supply from the hot well and pumps into the boiler. The long vertical pipe shown on the drawings is the air chamber for the feed pump. The feed pump is single acting, and consequently needs quite a large air chamber. The horizontal cylindrical apparatus shown alongside of the condenser, on which apparatus it will be noticed a gage glass is mounted, is a trap used for draining the steam jackets. In this trap is a large counterbalanced float of granite mounted on a lever which operates a single-seated valve. The trap is made of unusually large proportions, with the view to making it certain in its action, as it has to open a single-seated valve against a pressure of 130 lbs. per sq. in.

The foregoing description gives a pretty clear idea of the main features of the Nordberg pumping engine, and especially of the steam valve gear, upon the efficient operation of which the designer, Mr. Bruno V. Nordberg, M. Am. Soc. M. E., lays considerable stress. Mr. Nordberg informs us that the engine illustrated has shown an economy of 125,000,000 ft-lbs. per 1,000 lbs. of water evaporated, which is a quite remarkable exhibit.

For the information from which this article has been prepared, we are indebted to the Nordberg Mfg. Co., of Milwaukee, Wis.

The United States steel harbor-defense ram "Katahdin," was put into commission on Feb. 20, at the Brooklyn Navy Yard. The "Katahdin," built at Bath, Me., has a displacement of 2,183 tons, and engines of 4,800 I. HP. She is 250 ft. 9 ins. long, 43 ft 5 ins. beam and 15 ft. draft. Her main weapon of defense is her ram; as she carries but four 6-pdr. rapid-fire guns. But her engines and all machinery are below the waterline, and there is little appearing above except an armored deck, a conning tower and the smoke-stack. Her contract price was $930,000 and contract speed 17 knots. She did not quite meet the latter specification.

The coast defense monitor "Monadnock" has been placed in commission after twenty years of so-called repairs. She was originally built in 1865, but in 1874 she was torn to pieces and practically rebuilt. She is 259 ft. 6 ins. long, 55 ft. 10 ins. beam and 14 ft. 6 ins. draft, with a displacement of 3,990 tons and engines of 3,000 I. HP. Her contract speed is 14½ knots, and her main battery contains four 10-in. breech-loading rifles and two 4-in. rapid-fire guns, with a secondary battery of 6 and 3-pdr. rapid-fire and Hotchkiss guns. Her turrets have 7½ ins. of armor with 11½ ins. in the barbettes. The "Monadnock," in her original form, twice made the voyage round Cape Horn.

The cophone is a device invented by Mr. Della Torre and intended to assist mariners in locating other vessels in a fog. The somewhat complicated instrument is a double concave sound-vane, so arranged that a sound striking one side of the vane is not reflected to the other. Each side of the vane has a tube running to a leather helmet, and to the right and left ears of the operator. In a late test in New York harbor the inventor accurately located the direction of a tug which was circling about and whistling, though Mr. Della Torre was so placed that he could not see it. A number of experiments were tried by the inventor and by others, with uniform success.

The Red Jacket shaft of the Calumet and Hecla copper mines is 4,900 ft. deep. This shaft was started in the fall of 1889, and has been continuously pushed since, until it reached the conglomerate lode and the limit of the company's underground territory on Feb. 14. It is said to be the largest shaft in the world, being 14x22½ ft. inside. It is divided into six compartments, and is timbered throughout, requiring more than 10,000,000 ft. b m. of Georgia pine. The hoisting plant, already in place, includes two pairs of triple expansion engines of 3,000 HP. each, capable of lifting 10 tons at the rate of 3,600 ft. per minute. The shaft-house now being built will be made of steel and will be fireproof.

A combination paving block for street paving is being tried in Chemnitz, says U. S. Consul Monaghan. These blocks are made by dressing the top surface of a stone and then setting this stone, face down, in a mould of wood or sheet iron. Small stones are then placed on this and the interstices are filled with a mixture of 1 part Portland cement to 1½ or 2 of clean, sharp sand. The blocks are taken from the mold in 24 hours and are left 4 weeks before using. The only advantage claimed is cheapness, as these artificial blocks are said to cost one-half to one-third less than squared stone blocks, and are claimed to be fully as durable and even more elastic and less liable to weather influence.

Philadelphia still has in its streets 56,731 wood and iron poles; maintained by the various electric companies, and 41,750 of these belong to the street railway companies using the overhead trolley system. In addition to the above total there are 6,333 wood and 1,764 iron poles belonging to the city police and fire systems. There are in use 2,676 miles of overhead telegraph and telephone wires, 1,325 miles of electric light wire, 1,415 miles of city wires, and 570 miles of trolley wires; making a total of 5,986 miles of overhead wire. The total of underground conduit amounts to 2,196,334 lin. ft., containing almost 300 miles of ducts. The city owns 190,543 lin. ft. of these conduits, with 1,291,887 lin. ft. of ducts; and in the last year received $5,464.58 in rentals for their use.

Paving blocks of paper pulp are to be laid on a short section of a street in Topeka, Kan., as an experiment. The blocks are said to resemble vitrified bricks, but are much lighter. Mr. Wm. P. Emery, of Topeka, the inventor and manufacturer of this novel paving material, was recently given permission to lay a short section for trial under the supervision of the Street Commissioner and the City Engineer, Mr. Wm. H. Barnes. We are indebted to Mr. Barnes for the above information.

WEATHER TABLE FOR JANUARY, 1896. (Furnished to Engineering News by the Department of Agriculture.)

	Stations.	Temperature. (Degrees Fahrenheit.)				Wind.			Precipitation—rain or melted snow—inches.		
						Velocity in miles per hour.		Direction at time of max. velocity.			
		Average.	Max.	Min.	Range.	Average.	Max.		Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	13.2	39	22	61	7.4	40	SW	.87	.50	13
	Portland, Me.	20.6	43	13	56	7.4	26	W	2.00	1.18	9
	New York City.	27.6	47	3	50	15.0	48	NE	1 25	.93	6
	Pittsburg, Pa.	31.3	56	2	58	6.9	24	NW	1.63	.27	10
	Chicago, Ill.	27.0	50	9	59	15.8	44	S	1.12	.58	10
	Omaha, Neb.	27.3	63	8	71	7.5	26	NW	.33	.16	5
	St. Paul, Minn.	15.6	44	18	62	7.8	29	NW	.81	.19	11
	Duluth, Minn.	13.4	42	25	67	8.6	42	NW	1.30	.32	13
	Bismarck, N. Dak.	8.1	48	23	71	9.3	46	NW	.81	.32	7
	Average.	20.5	48	14	62	9.5	36		1.12	.55	9
Southern Cities.	Washington, D. C.	33.3	59	8	51	7.4	34	NW	2.27	1.94	4
	Louisville, Ky.	35 6	61	3	58	7.9	27	NW	.82	.29	10
	St. Louis, Mo.	35.0	62	5	57	10.5	32	NW	1.43	.97	7
	Savannah, Ga.	49.0	70	22	48	7.3	36	NW	4.32	2.53	7
	Kansas City, Mo.	31.4	55	0	55	7.8	28	N	.79	.49	8
	Jacksonville, Fla.	53.5	75	24	51	6.0	28	SW	2.53	1.12	9
	Chattanooga, Tenn.	41.6	64	12	52	6.8	28	W	2.90	.93	9
	New Orleans, La.	52.2	76	28	48	8.7	30	N	2.33	.71	10
	Memphis, Tenn.	41.8	65	14	51	9.3	30	S	4.32	1.11	15
	Palestine, Tex.	49.6	73	20	53	6.7	28	SW	7.67	2.92	9
	Average.	42.3	66	14	52	7.8	30		2 94	1.30	9
Western Cities.	Helena, Mont.	23.6	52	20	72	6.2	34	SW	.72	.27	9
	Port Angeles, Wash.	39.0	59	25	34	5 9	27	W	5.07	1.30	17
	San Francisco, Cal.	52.2	63	40	23	9.5	47	S	8.14	1.85	14
	Salt Lake City, Utah.	31.0	54	9	45	5.7	36	S	1.26	.34	9
	Santa Fe, N. Mex.	33.9	54	11	43	6.3	26	NE	.36	.13	5
	Denver, Col.	37.4	67	0	67	8.6	66	SW	.25	.12	4
	Yuma, Ariz.	57.8	81	31	50	5.9	28	NE	.14	.14	1
	Average.	39.7	61	14	48	6.9	38		4 28	.59	8